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A REVIEW OF APPLIED ENTOMOLOGY IN THE BRITISH EMPIRE.*

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*The Annual Address to the Entomological Society of America, delivered at Columbus, Ohio, on December 29th, 1915.

In the selection of the subject of my address I had as my main motive the bringing of the entomologists of this country into closer touch with a large body of entomologists who are studying an infinite variety of problems in those widespread territories of the earth's surface that together constitute the British Empire. This more intimate acquaintance is desirable for many reasons, but I will refer only to two of them. First, our Society recently decided to extend its membership outside the confines of North America and as a result a number of British workers, which number I am confident will increase, have been included on our membership rolls; I wish to introduce these members and some of their problems to you. Secondly, it is becoming increasingly apparent that the control of insect pests and the successful prosecution of entomological investigation, be it along practical or purely scientific lines, must be along international lines. Our experience, especially during recent years, has clearly demonstrated this fact, particularly in regard to the control of insects by their natural enemies. From the time when Koebele visited Australia in 1885 and brought the now famous Coccinellid *Novius cardinalis* to save the citrus groves of California from destruction up to the recent world tour of Silvestri in search of parasites of the fruit-flies, we have had repeated instances of the incalculable value of international co-operation; but it would involve too great a digression to mention even the more important of these. In this line of investigation alone there lie immense possibilities which will be made more easy of realization to the benefit of all concerned by a more intimate knowledge of other workers and their problems in other parts of the world. Such a review as I propose to give will, I feel confident, show clearly how the British Empire by its widespread character and diversity of conditions of every kind, offers an unequalled opportunity for international co-operative effort, particularly to the Entomologists of the United States. The establishment of a chain of workers in all the continents which would result from such co-operation would have beneficial results of the most far reaching character on the entomological work of the future. If I am able to further the object to which I have referred, I shall consider that the time I am about to take up has indeed been well spent.

The countries that enjoy the benefits of British forms of government comprise territories from equatorial to arctic and antarctic latitudes; they include some of the most worthless and barren regions of the world's surface and some of the richest and most fertile. Consequently we find every type of vegetation, every kind of crop and every form of insect life to which such vegetation or crop may serve as sustenance. In addition there are few types of insect-borne disease that are not found somewhere within British domains. It will not be possible, therefore, to do more than briefly touch upon the more outstanding features of the work that is being carried on in those countries by an ever increasing body of highly trained and enthusiastic workers. And here I would remind you that it is one of the chief characteristics of the British entomologist that he usually follows his profession on account of his enthusiasm for the subject, and in spite of the remuneration that he receives and the natural difficulties with which he has to contend.

British Isles.

The Imperial Bureau of Entomology.—The formation of the Imperial Bureau of Entomology in 1913 was the outcome of an effort made a few years earlier to further entomological investigations in the British possessions in tropical Africa. Early in 1909 Dr. A. E. Shipley, Master of Christ's College, Cambridge, drew up a memorandum, with some slight assistance from me, for the Secretary of State for the Colonies, Lord Crewe, and as a result of this a meeting was called in March, 1909, to discuss the formation of an entomological research committee for the stuty of entomological problems, particularly those relating to tropical diseases, in tropical Africa. Such a committee was formed that year and it included the chief experts in entomology and tropical medicine in Great Britain and Ireland, with Lord Cromer as Chairman. Its work fell under three divisions, namely, the carrying on of investigations and entomological surveys in tropical Africa, for the purpose of which two travelling entomologists, Mr. S. A. Neave and Dr. J. J. Simpson, to whose work reference will be made later, were employed; the determination of entomological material, and the publication of the work so accomplished, for which purpose the *Bulletin of Entomological Research* was started as a quarterly journal.

The valuable service rendered by this committee soon led to an enlargement of its scope. After a consideration of the matter by the self-governing dominions, and a conference of the committee and of the entomologists of some of the dominions and colonies in 1912, a scheme for imperial co-operation in preventing the spread and furthering the investigation of noxious insects was worked out. This conference put forward a proposal for the establishment of an Imperial Bureau of Entomology, to be financially supported by the various dominions and colonies and the British government. The scheme was adopted by the various self-governing dominions and colonies which were invited to co-operate and contribute to the maintenance of the Bureau, and the crown colonies and British protectorates are also participating in the advantages of the Imperial Bureau of Entomology which was established in 1913 with headquarters in London. The former Entomological Research Committee has become the Honorary Committee of Management on which committee the government entomologists of the dominions are also members. The Rt. Hon. Lewis Harcourt, former Secretary of State for the Colonies, is Chairman of the Committee and Dr. Guy A. K. Marshall is Director of the Bureau and Editor of its journals.

The functions of the Bureau are as follows:

1. The collection and co-ordination of information concerning the noxious insects of the world so that any British country may learn by enquiry what insect pests it is likely to import from other countries and the best methods of preventing their introduction and spread.

2. The authoritative identification of insects of economic importance submitted by the officials of the Departments of Agriculture and Public Health throughout the Empire.

3. The publication monthly of the *Review of Applied Entomology* in which concise summaries or abstracts are given of all the current literature which has a practical bearing on the investigation and control of noxious insects.

4. The investigation of blood-sucking insects, particularly in Africa. At present all the field staff are engaged in studying the bionomics of the various species of *Glossina;* the special object of their investigations is to endeavour to devise some practical means of reducing the numbers of or eradicating these

carriers of the different types of *Trypanosomes*. The men engaged in this work are Mr. W. F. Fiske and Dr. G. D. H. Carpenter, in Uganda, Dr. W. A. Lamborn in Nyasaland and Dr. J. J. Simpson in the Gold Coast.

The work of the Bureau is wholly different from that of the United States Bureau of Entomology. Its primary function is that of an intelligence bureau, a clearing house for entomological information, collecting such information for the use of the British countries supporting it. It has already accomplished a large amount of useful work and has been of particular assistance to those isolated and scattered British territories where the entomologists and medical officers suffer from lack of museums, libraries and co-workers which they would wish to consult. International as the scope of its survey necessarily is, it has already demonstrated how valuable a similar Bureau properly constituted on international lines might prove.

England. The British Government in the past has not maintained an official entomologist or entomological staff. The Board of Agriculture and Fisheries has been content to retain the services of an outside entomologist to prepare replies to any entomological inquiries submitted to it by farmers and others, and their leaflets have been chiefly the work of unofficial advisers. In the absence of an official entomological staff the investigation of insects affecting agriculture has been left in the hands of men such as Prof. F. V. Theobald of the South Eastern Agricultural College who is now making a much needed study of the British aphides and whose work on mosquitoes is well known, Mr. C. Warburton of Cambridge, Prof. Newstead of Liverpool, Mr. W. E. Collinge, and others.

It is perhaps difficult on this continent to understand the underlying reason for the scant development of "official" entomology in England. But it must be pointed out that agricultural conditions are entirely different in such old countries where there is a more intensive system of farming, a consequent closer supervision of crops, cleaner cultivation and long developed systems of rotation. More especially, the comparative stability of the agricultural conditions has produced a more perfect balance in all those natural conditions the disturbance of which in more lately developed countries leads to an abnormal behaviour of the insects which are potentially noxious. These facts should, therefore, be borne in mind

in considering the apparent lack of any extensive development in applied entomology in the older European countries.

In 1912 the Horticultural Branch of the Board of Agriculture and Fisheries was established under the direction of Mr. A. G. L. Rogers. This branch has the administration of the Destructive Insects and Pests Act to carry out which legislation five trained inspectors are employed. Their work, however, is at present largely concerned with plant diseases. An advance was made in 1913 when Mr. J. C. Fryer was appointed Entomologist to the Board. His work is primarily of an advisory character, advisory to the Board in regard to legislation and to the public by means of letters or leaflets. He also studies epidemic pests and insects of unusual importance. For example, Mr. Fryer has begun a study of the species of *Hyponomeuta* the Ermine Moths, whose introduction into the State of New York afforded Mr. P. J. Parrott an opportunity of studying them in a new environment. The Narcissus Flies, *Merodon equestris* and *Eumerus strigatus* have also been studied. Mr. Fryer informs me that he is now studying *Hylemyia coarctata* a serious wheat pest in low-lying marshy districts. Capsid bugs, which cause similar injuries to fruit to those with which we are familiar in the northeastern region of North America, are also receiving attention.

Entomological investigations are also conducted at certain of the universities by means of grants from a Government Development Commission Fund. It would appear to be the intention to foster the investigation of insect pests in recognised university departments rather than in a department of the government, a plan which has advantages and disadvantages which I will not discuss here. As a result there is a Department of Agricultural Entomology at the University of Manchester under Dr. A. D. Imms, and forest insects are studied at the University of Oxford. Prof. Maxwell Lefroy of the Imperial College of Science and Technology, London, has also been conducting investigations in applied entomology.

Scotland. A few years ago a separate Board of Agriculture for Scotland was established and Dr. R. Stewart McDougall of the University of Edinburgh acts as Entomologist to the Board. Dr. McDougall's work is largely concerned with forest insects but his work on the Sheep Maggot Flies, *Lucilia* spp., is well known.

Ireland. Prof. G. H. Carpenter of the Royal College of Science, Dublin, acts as Entomologist to the Department of Agriculture and Technical Instruction of Ireland and publishes an annual report on economic entomology in the Proceedings of the Royal Dublin Society. Prof. Carpenter's investigatory work during a number of years has been confined chiefly to the study of the Warble Flies, *Hypoderma bovis* and *H. lineata.*

AFRICA.

On no other continent in the world has the struggle between insect and man been so acute as on this immense area containing tropical and sub-tropical conditions, and nowhere has the insect been so victorious or so securely entrenched in regions offering every advantage to it and every obstacle to man. The mosquito has held the key to some of the richest regions of the earth's surface, the Tsetse fly has rendered extensive transportation impossible, and the tick, if one may be permitted to use entomology in its broad sense and include ticks, has kept the white man at bay and devastated his herds. But by slow degrees the power is passing from insect to man and nowhere is the conquest of such an adverse and powerful force of nature by patient effort illustrated more strikingly than in the gradual conquest, in the real sense, of Africa. The West Coast is no longer a "White man's grave," as it was formerly called, nagana and tick fevers are losing their original terrors and we should be unworthy of our traditions did we believe that sleeping sickness would always remain the scourge that experience has demonstrated it to be within recent years.

The British territories in Africa are so situated that it has fallen to the lot of our investigators to contribute largely to this notable conquest, the history of which would constitute one of the finest examples of entomological achievement that we have. But to attempt to outline such a history would exceed the limits which must necessarily be set to this account of the manner in which the work is being carried on at the present time.

The Union of South Africa. Prior to the formation of the Union of South Africa the four colonies, Cape Colony, Natal, Transvaal and the Orange Free State, carried on their entomological work independently. Cape Colony which created a Division of Entomology with Mr. C. P. Lounsbury as Chief in 1895, was the most advanced. Following the union, Mr.

Lounsbury was made Chief of the new Division of Entomology of the Union Department of Agriculture with headquarters at Pretoria. The work of this Division comprises, in addition to the dissemination of advice on insect problems and the carrying on of investigations, the administration of government regulations concerning (1) the suppression of locusts, (2) the inspection of nurseries (3) plant and fruit imports, and (4) restrictions on the conveyance of plants and fruit. At Pretoria Mr. Lounsbury has Mr. Claude Fuller, former Entomologist for Natal, as Assistant Chief and is also assisted by Mr. D. Gunn and several inspectors. The following branch laboratories are also maintained: Capetown, with Mr. C. W. Mally in charge; Bloemfontein, Mr. J. C. Faure in charge of investigations in the Orange River Colony; and New Hanover, Natal, with Mr. C. B. Hardenberg in charge. In addition to the staffs at these laboratories, plant inspectors are stationed at the following ports of entry for plants and fruit: Capetown, Johannesburg, Durban, East London and Port Elizabeth. The agricultural situation in South Africa is peculiar owing to the fact that agriculture is not yet the basic industry of the country. The greater part of the agricultural lands is devoted to live stock, and the cultivation of the land is proceeding gradually. Nevertheless, the climatic conditions are eminently suitable to the cultivation of deciduous and citrus fruits with the result that progress in this direction is being made.

The development of a fruit-growing industry has naturally demanded a vigilant policy in the matter of preventing the introduction and spread of foreign fruit pests and the policy has been to restrict importations of nursery stock and to foster local nurseries. On this account nursery inspection constitutes the prominent feature of the work of the Division of Entomology. This work and the inspection of imported nursery stock and fruits and regulation of the transportation of home grown fruit is carried out under the Agricultural Pests Act of 1911.

To retard the spread of the codling moth which was introduced into the country, apple, pear and quince fruits may not be transported into certain areas. Equally stringent measures were adopted to prevent the spread of San Jose scale (*Aspidiotus perniciosus*). Undoubtedly the control of locusts constitutes one of the most serious problems in South Africa. Of the two species of migratory locusts the brown

locust *Pachytilus sulcicollis* is more serious than *Schistocerca peregrina.* From the Kalahari Desert, in what has hitherto been called German South West Africa, which is the permanent habitat of the species, vast swarms migrate to Central and Eastern Cape Colony, Transvaal, Orange River Colony and Rhodesia and breed there. These swarms sometimes have a frontage of fifteen to twenty miles and a length of sixty to seventy miles and take several days to pass a given point. They devastate the veldt of all green food with serious results; in 1906 it was estimated that the locust damage in South Africa amounted to five million dollars. The control of these locusts is regulated by law. Farmers are required to report the laying of the eggs and the appearance of the young hoppers. They are also required to destroy the young hoppers and the government furnishes the poison. Arsenite of soda mixed with water and molasses or sugar is universally used and with success over large areas, the poison being usually applied by means of bucket pumps which are loaned to the farmers. This campaign necessitates the keeping in stock of a large store of prepared poison and a supply of pumps for any emergency.

Notwithstanding the large amount of administrative work, the entomologists in South Africa have undertaken important lines of investigation. Mr. Lounsbury's work on ticks is well known and Mr. C. W. Mally's name will always be remembered where poisoned baits for fruit-flies are used. Mr. Fuller has also contributed to our knowledge of the termites and Mr. Hardenberg has made extensive studies of the insects affecting the wattle.

The tick problem is a very serious one in South Africa, several most important diseases of live stock being transmitted by these agents. Of these diseases East Coast Fever, due to the protozoan parasite *Theileria parva*, which is carried by several species of ticks of the genus *Rhipicephalus*, is the most serious and has played great havoc. In addition the disease included under the general term Piroplasmosis namely, bilary fever in horses and redwater in cattle, are serious adverse factors in the main type of agriculture followed in South Africa. Fortunately the Veterinary Branch of the Department of Agriculture has attacked the tick problem in a vigorous manner along well known lines, no little credit being due to the work of Dr. Arnold Theiler.

Rhodesia. The entomological problems of Rhodesia are ɔt very dissimilar on the whole to those of South Africa, though there are certain lines of inquiry which are peculiar › this region. Mr. R. W. Jack, the Government Entomologist ɪs his headquarters at Salisbury and is assisted by Mr. R. L. hompson. Their work follows along the usual lines outlined ι the case of South Africa. Under the "Importation of lants Regulations" and "Nurseries Ordinance" the Govern- ɪent prevents the introduction and spread of insect pests and :ant diseases. Four ports of entry have been established, ɪmely, Salisbury, Bulawayo, Umtali and Gwelo, at which ɪmigation houses are maintained. Nurseries must register ıd are inspected annually.

The country is subject to locust plagues and native com- ɪissioners, cattle inspectors and members of the British South frican police are required to report with full details any swarms, ɪr the control of which locust poison, spray pumps, etc., are ept on hand. The Government protects the chief bird enemies : the locust, such as the White Stork, Cattle Egret, Lesser ocust Bird and Wattled Starling.

Much attention has been devoted by Mr. Jack to the :udy of Tse-tse flies and each year he devotes a portion of is time to travelling through the "fly" belts for the purpose : making bionomical investigations and delimiting the areas : these belts. Areas infested with *Glossina morsitans* are efined by government regulations and adjacent areas, or open areas" are also defined in which the destruction of all ɪme, with the exception of ostriches and certain game birds, is ermitted. The results of Mr. Jack's investigations have been ublished in the *Bulletin of Entomological Research*.

Other investigations are mainly concerned with pests of the ɪore important crops, such as corn (maize), citrus fruits and ›bacco and with the pests of lesser cereals, field crops, vege- ıbles and stone fruits. The wide range of plants and trees ıltivated on the high and low parts of the territory offer an nusual broad field for research. Tenebrionids are very ɔmmon and have been studied and also pests of corn (maize). . formidable problem is afforded by certain fruit-piercing ɪoths belonging to the genera *Maenas*, *Ophiusa*, *Achaea* and *phingomorpha*, which severely injure practically all fruits.

The control measures are not specially peculiar, although where cheap coloured labour is available hand-picking may be more commonly used than in other countries dependent upon white labour. A long dry season enables advantage to be taken of clean cultivation. Owing to the fact that the country is being opened up by a keen class of agriculturists who are experimenting with new crops and are not bound by the hard and fast traditions of old farming communities, the entomologists are frequently consulted and co-operation in experimental work is readily secured.

Uganda. In this rich tropical country offering great opportunities for entomological investigations, Mr. C. C. Gowdy carries on his work as Government Entomologist single-handed. The study of the Tse-tse fly problem is not carried on by the Department of Agriculture, but independently of this Department, as I shall show later. Mr. Gowdy is stationed at Kampala and the size of the country and methods of travel, namely, by the use of porters, do not permit of a very thorough study of any one problem, especially as his only assistants are natives, who are constitutionally lazy, but nevertheless make good collectors.

The importation of plants and seeds is regulated by Government Ordinances. There is a single port of entry, Kampala, and there all imported plants are inspected and, if necessary, fumigated. The importation of cotton seed is prohibited; all plants from Ceylon, coffee plants and coffee other than roasted beans and ground coffee, are prohibited without special consent. A Plant Pest Board has been created, one of its objects being to facilitate the reporting of the existence of pests and the enforcement of preventive or remedial measures.

The chief entomological problems relating to agriculture in Uganda are connected with principle crops, namely, cotton, coffee, cacao and Para rubber. Termites and locusts also demand attention.

Undoubtedly the most serious entomological problem in Uganda at the present time is the suppression of sleeping sickness by the control of the Tse-tse fly. For about thirteen years this disease, which in the earlier part of the last decade was responsible for the deaths of several hundred thousands of the inhabitants of Uganda, has been studied at Entebbe by the

Sleeping Sickness Commission, on which Sir David Bruce has been the principal worker. The entomological aspect of the question was not specially studied until comparatively recently, but now it is receiving more of the attention it deserves, and I have referred to the fact that the Imperial Bureau of Entomology has two investigators at work in Uganda, namely, Mr. W. F. Fiske, formerly of the United States Bureau of Entomology, and Dr. G. D. H. Carpenter, who have already added substantially to our knowledge of the bionomics of the Tse-tse flies. In the adjacent British territory of Nyasaland, Dr. W. A. Lamborn of the Imperial Bureau of Entomology is studying the Tse-tse fly problem.

British East Africa. The Department of Agriculture has as its Chief Entomologist Mr. T. J. Anderson, who is stationed at Nairobi, the headquarters of the government of the Protectorate. He has an assistant, a Plant Import Inspector and a staff of native collectors. The careful examination of all plants, seeds, etc., entering the Protectorate is undertaken by the Plant Import Inspector under the Regulations of the Disease of Plants Prevention Ordinance, 1910. There are special regulations relating to coffee and cotton. Facilities are provided at the Government Experimental Farm where the entomological laboratory is situated for the carrying on of entomological investigations. The most troublesome insect pest perhaps is the coconut beetle (*Oryctes monoceros*). The antestia bug (*Antestia variegata*) is very injurious to the coffee plants. Experiments are now being carried out on the control of the latter pest by an Ichneumon parasite.

Egypt. Previous to the creation of a Department of Agriculture in 1910, the Ministry of Interior and the Khedivial Society of Agriculture undertook the study of insect pests, Mr. F. C. Willcocks being the Entomologist of the Society and the Yearbooks of the Society contain the results of his numerous investigations, particularly on the Egyptian cotton worm (*Prodenia litura*) and the Egyptian cotton boll-worm (*Earias insulana*). Insects affecting cotton have received the greatest attention on account of the increasing importance of that crop. Under the Ministry of Agriculture which was organized in 1913, the cotton worm, boll worm and locust campaigns are carried out by the Administrative Division independently of

the Entomological Section. The Entomological Section is part of the Technical Division of the Ministry of Agriculture. The Consulting Agriculturist, Mr. G. C. Dudgeon, who is also an entomologist, is head of the Technical Division The Director of the Entomological Section is Dr. Lewis H. Gough, who is assisted by Messrs. G. Storey and E. W. Adair. In addition a staff of Egyptians under Dr. Gough's direction has charge of the inspection and fumigation of imported plants, which are treated at the port of entry. The fumigation of citrus trees, with a view to controlling *Aspidiotus aonidum*, which is a severe pest of oranges in the Delta region, is carried on by the Government fumigation brigades. Among the tropical fruit pests may be mentioned the pyralid moth *Ephestia cautella*, which seriously injures dates in some sections, and the butterfly *Virachola livia*, which attacks pomegranites.

In Egypt one meets in a striking manner the difficulties which confront the entomologist who has to deal in tropical countries with native agricultural labourers. These difficulties necessitate the control of insects, as far as possible, without the use of poisons or spray pumps. The native agricultural labourer is very ignorant and very careless and cannot be entrusted with poisons or with machines that are not entirely fool-proof. This accounts for the manner in which the annual campaign against the pests of cotton, the cotton worm and the boll worm is conducted by the Administrative Division. The regulations governing these campaigns provide for the hand-picking of the egg masses of *Prodenia litura* on the cotton leaves, and the reduction of the numbers of the boll worms is attempted by ordering and enforcing the destruction of all cotton bolls at a certain date each year after the final picking. Incidentally, it may be mentioned that persons who have been imprisoned for contravening the cotton worm laws are condemned to carry out these control measures. The pink boll worm of cotton *Gelechia gossypiella* was introduced into Egypt a few years ago with disastrous results, and methods for the control of the *Gelechia* larvae in cotton seed on a commercial scale are now being investigated; at present the treatment of seed, the destruction during the winter of cotton sticks and wood stored for fuel is required by law.

Reference should also be made to the work in Egypt of Mr. A. Andres, one of the inventors of the Andres-Maire bait traps for moths, to which reference is made in discussing the control of insects in India.

Sudan. The entomological work for this country is carried on by Mr. H. H. King, who is Entomologist to the Gordon Memorial College at Khartoum, the seat of Government. Mr. King's work has been largely confined to the study of the blood-sucking insects which are naturally of paramount importance in that region and his investigations on mosquitoes, and particularly on Tabanidae are furnishing valuable results.

In passing attention should be called to regulations governing the examination of persons entering the Sudan from Uganda for sleeping sickness. Such persons must proceed to Mongalla for examination by the Medical Officer there. There are also restrictions on trade with Uganda; it may only be carried on by licensed persons.

Locust outbreaks constitute a serious trouble from time to time in the Sudan, *S. perigrina* being the chief species and the use of poisoned bait, poisoned with sodium arsenite has been employed with success.

British West Africa. The British territories consist of the colonies of Gambia, Sierra Leone, the Gold Coast, Lagos, and Northern and Southern Nigeria. In these rich tropical regions the agricultural products are very varied, including not only such native products as rubber, palm oil, cacao and various native nuts, etc., but cultivated crops such as cotton, the development of which industry is progressing, rice, coffee, and corn (maize). The greatest obstacle to agricultural development under European direction has been the widespread occurrence of malaria, which for many years rendered permanent residence impossible to Europeans. To a lesser degree other tropical diseases contributed to the difficulties of existence and agricultural expansion. Fortunately, it has been possible in recent years by the adoption of the necessary anti-malarial measures to remove to an encouraging degree so serious an obstacle, with consequent impetus to the development of those rich territories.

The development of entomological work, in so far as it relates to the study and control of insect pests affecting the

crops that are grown, has naturally been seriously handicapped by hitherto well nigh insuperable factors. Nevertheless, much pioneer work has been accomplished and a considerable amount of information has been collected regarding the insect pests occurring in the various territories. Mr. A. D. Peacock, late Entomologist for Southern Nigeria, has published an extensive report on the insect pests of that region and Mr. W. H. Patterson on the Gold Coast and Mr. A. W. Jobbins-Pomeroy in Nigeria, are prosecuting their investigations with a zeal that is not checked by the primitive and backward conditions of native agriculture, the difficulties of travel or the inadequacy of laboratory accommodation, assistance or entomological equipment. To those entomologists brought up and accustomed to work in the lap of luxury so far as facilities and apparatus for entomological investigations are concerned, the difficulties with which the British entomologists working in these tropical colonies have to contend are inconceivable. That they are able to accomplish so much is proof of their intense enthusiasm for their work and their ability to withstand conditions and surmount obstacles which would conquer any but the strongest natures.

The widespread prevalence of tropical diseases, particularly malaria and human Trypanosomiasis, led the Imperial Bureau of Entomology to undertake extensive surveys of the distribution of the blood-sucking insects of West Africa and Dr. J. J. Simpson has been conducting such an investigation. He has collected an enormous amount of valuable data and has made observations of great importance as a perusal of his numerous excellent reports which have been published in the *Bulletin of Entomological Research* will show. His investigations which are being continued at the present time constitute one of the most important phases of the Imperial Bureau's work.

AUSTRALIA.

A visitor to Australia is impressed with the abundance of insect life, particularly in the tropical and sub-tropical regions of the continent and, while little more than the fringe of the possible agricultural regions of the country has been utilized, if we except the sheep grazing sections, where production of deciduous and citrus fruits and sugar is being actively developed, the inevitable disturbance of the natural equilibrium and the

introduction of new pests before quarantine restrictions are imposed, has followed. Fortunately, the continent appears to be well supplied with natural means of control of a vigorous kind, particularly as regards predatory insects such as ants and coccinellids, in fact Australia has always been the happy hunting ground for the lady-bird hunters.

The Commonwealth Government of Australia did not on its formation about fifteen years ago, assume any jurisdiction over agricultural matters, but left the individual states in full control. There is, therefore, no entomological work undertaken by the Commonwealth Government beyond the administration of the Federal Quarantine Act, which regulates the importation of plants, etc., into the country; this Act, I believe, is administered by the Department of Trade and Custom. As the entomological work is carried on by the various States independently it must be so described.

New South Wales. Agriculture is one of the principal industries of the State, the largest area being devoted to sheep grazing. Cereals, corn, tobacco, deciduous and citrus fruits and sugar cane are also grown successfully. Consequently the range of insect pests encountered in the State is extensive. The work of Mr. Walter W. Froggatt, the Government Entomologist is well-known. While his sphere is New South Wales, he carries on extensive correspondence with other parts of Australia, with New Guinea, Fiji and other islands of the Pacific. His experimental work is carried on at the various Experiment Farms in the State and at a small station at Narara experiments on the control of fruit flies, which constitute perhaps the worst insect pest on the continent, are conducted. Owing to the serious losses inflicted by various species of blowflies of the genus *Calliphora* on the sheep industry a special field station has been maintained for several seasons for the investigation of sheep maggot flies.

Under the State Vine and Vegetation diseases Act a large staff of inspectors is employed in different districts to see that the regulations concerning spraying, etc., are carried out. Imported fresh and dried fruits, seeds, etc., are subject to inspection and exported fruit is fumigated if required. An unusual line of work consists in the certification of freedom from the fowl tick (*Argas persicae*) of all the poultry going out of the State.

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Under the State Vine and Vegetation diseases Act a large staff of inspectors is employed in different districts to see that the regulations concerning spraying, etc., are carried out. Imported fresh and dried fruits, seeds, etc., are subject to inspection and exported fruit is fumigated if required. An unusual line of work consists in the certification of freedom from the fowl tick (*Argas persicae*) of all the poultry going out of the State.

ANNALS

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Under the direction of Dr. Frank Tidswell, Director of the Government Bureau of Microbiology, attention has been paid to insects concerned in the transmission of disease, particularly by Dr. J. B. Cleland, the results of whose investigations have been published in the Annual Reports of the Bureau.

Victoria. Agriculture in the State is of a general character, the area under cultivation, particularly in cereals, is increasing. Mr. C. French, Jr., is responsible for the entomological work, but little work of an investigatory character appears to be carried on. A large part of Mr. French's time is devoted to the administration of the Fruit and Nursery Inspection ordinances.

South Australia. About two thirds of the area of the State are farmed or grazed. The climate permits the growing of citrus fruits, almonds and olives and there is a considerable acreage under vineyards. The entomological work of the State is carried on by the Horticultural Division of the State Department of Agriculture at Adelaide. Strict measures are employed to prevent the introduction of the grape phylloxera and of other exotic insect pests by the usual methods of fumigation, etc. Nursery inspectors are also employed to carry on a campaign against the codling moth and scale insects affecting fruit.

Queensland. The State Department of Agriculture has maintained an Entomologist since 1897 and the name of the Government Entomologist, Mr. Henry Tryon, who has his headquarters at Brisbane, is known to most entomologists. The varied climatic conditions of the State permit the existence of an extensive range of insect pests, affecting in addition to the usual agricultural crops and fruits, such tropical and subtropical crops as cotton, sugar, pineapples, bananas, coconuts and coffee. Mr. Tryon has recently returned from a world's tour taken for the purpose of investigating the methods by which the prickly pear may be destroyed. Much of the Entomologist's time is occupied in travelling about the State. Insects affecting sugar cane receive, perhaps, the most attention, a special field station for their investigation being maintained at Gordonvale, near Cairns. In the sugar-cane growing district Grub Pest Destruction Committees exist for the purpose of encouraging the destruction of sugar-cane insects, particularly the beetle *Lepidoderma albohurtum.*

Imported and exported fruits and fruit grown and sold in the State are inspected under State regulations by a staff of inspectors and the inspection of nurseries is also carried out.

The existence of insect borne diseases in the State has resulted in attention being paid to this branch of entomology and at the Tropical School of Medicine at Townsville Mr. F. Taylor has carried on some excellent work on blood-sucking Diptera, particularly *Culicidae* and *Tabanidae*.

Tasmania. The entomological work of the Island State is conducted in conjunction with the phytopathological work and advice on the control of insect pests is also given by the Fruit Expert. Imported fruit is inspected and local Fruit Boards administer the provisions of the Codling Moth Act.

Western Australia. The agricultural productions of this State whose cultivated lands fringe the western coast of the continent consist mainly of cereals, fruit and wines. Large areas suitable for the cultivation of the vine, olive and silk could be opened up if labour and means of transport were procurable. An Entomologist has been maintained since 1898 and the present occupant of the position is Mr. J. L. Norman, with headquarters at Perth. An inspection service is maintained for the supervision of imported vegetation and the nurseries in this State, and modern methods of dealing with insect pests affecting fruit are very generally followed.

Northern Territory. Little work on economic insects has been carried out in the State owing no doubt to the lack of agricultural development. But the Government Entomologist, Mr. Gerald F. Hill, who is stationed at Darwin, has made some valuable and interesting contributions to our knowledge of the Termites. Recently he has been studying the relation of blood-sucking flies to the transmission of parasitic nematode worms, and he will no doubt have excellent opportunities for further work on veterinary and medical entomology.

CANADA.

The interest in each other's work and the spirit of co-operation that exists between Canada and the United States renders an enumeration of our entomological problems unnecessary, for owing to the fact that we share the same continental area without any barrier greater than a parallel of latitude and a

few rivers and lakes we are compelled to experience many of your entomological troubles and to receive the generous overflow your hospitality to foreign invaders provides. But while we may have to study the control of the same insects that occur in the United States, it does not necessarily follow that our methods will be the same. In many cases the environmental conditions in Canada, particularly in the matter of climate, are different with a resultant difference in insect behaviour and therefore in control. Accordingly, in our entomological work we are taking nothing for granted, except where we are compelled, but we are working out our own problems *de novo*.

While applied entomology was officially recognized in Canada as early as 1856 it did not have its real birth until 1869, six years after the establishment of the Canadian Entomological Society, now the Entomological Society of Ontario by reason of a provincial grant and charter. The recognition and support of this Society by the Province of Ontario constituted the only official step in applied entomology until the appointment of Dr. James Fletcher by the Dominion Government in 1884 as Government Entomologist. The Dominion Experimental Farms were established in 1886 and to this Branch of the Department Dr. Fletcher was attached as Entomologist and Botanist until his death in 1908. A separate Division of Entomology of the Experimental Farms Branch was then created and I was entrusted with the organization on my appointment in 1909 as Dominion Entomologist. In 1910 the Destructive Insect and Pest Act was passed and in 1911 the first Dominion Field Laboratory was established; these two facts are indicative of the two chief lines of the Dominion work—administrative and investigatory—and the development of the work along these special lines led in 1914 to the separation of the entomological service from the Experimental Farms Branch and its elevation to the status of an independent Branch of the Department of Agriculture. The sanction of the Dominion Parliament to increased appropriations which are now more in accord with the needs of the country is encouraging evidence of a desire to afford the means whereby the entomological service of the Dominion shall be in a better position to meet the requirements of the situation.

We have now nine field laboratories and two sub-stations. The laboratory at Annapolis Royal, N. S., serves as headquarters for the control work and bionomical studies of the brown-tail moth. Mr. G. E. Sanders, the officer in charge, is also investigating the bud-moths and green-fruit worms of apple and their control and is conducting insecticidal investigations. A sub-station is situated at Bridgetown, N. S., at present.

A new and commodious laboratory building in Fredericton, N. B., serves as headquarters for the work in New Brunswick, of which Mr. J. D. Tothill and Mr. L. S. McLaine have charge. Mr. Tothill is in charge of the colonization of the parasites and predatory enemies of the brown-tail and gipsy moths which enemies, through the courteous co-operation of Dr. L. O. Howard, Chief of the United States Bureau of Entomology, we are collecting and importing from the New England States. In addition Mr. Tothill is conducting an intensive study of the natural control of three of our widely spread and periodically destructive insects—the tent caterpillar (*Malacosoma disstria*) the spruce budworm (*Harmologa fumiferana*) and the fall webworm (*Hyphantria cunea*). It is our intention to continue this study over a number of years. The results secured during the past two or three years have indicated the value and necessity of such an intensive study. Mr. McLaine has charge of the field work against the brown-tail moth in the winter on which a force of seventeen to twenty inspectors is engaged, and in the summer he is stationed with two assistants at the Gipsy Moth Laboratory, Melrose Highlands, Mass., in connection with the breeding of the parasites of the brown-tail and gipsy moths.

At a field laboratory situated at Hemmingford, Quebec, a little south of Montreal, Mr. C. E. Petch is investigating the apple and plum curculios, and other insects affecting apple in connection with which experimental and demonstrative work on spraying is conducted in a number of orchards. Mr. Petch has also been carrying on experiments for three seasons on the control of locusts by means of the *Coccobacillus acridiorum*.

There are two Field Laboratories in Ontario. At Vineland in the Niagara fruit district, Mr. W. A. Ross is in charge of a laboratory where fruit insect investigations are mainly carried on. For four seasons Mr. Ross has been studying the control of the apple maggot (*Rhagoletis pomonella*). Two years ago

he commenced an investigation of the aphids affecting apple: *Aphis sorbi*, *A. pomi* and *A. avenæ*, which are very injurious. Greenhouse and mill-infesting insects are also studied at this laboratory. At a laboratory at Strathroy, Ont., in the western part of the province, Mr. H. F. Hudson, who is at present on leave in Flanders, has investigated the chinch bug (*Blissus leucopterus*) and commenced a study of the white grubs (*Lachnosterna* spp.) which investigation is being continued in his absence by Mr. J. R. Gareau.

Our next Field Laboratory is situated at Treesbank in southern Manitoba and here Mr. Norman Criddle, whose work on locust control is well known, is investigating the bionomics and control of white grubs (*Lachnosterna* spp.) and in this connection I should mention that this investigation is complementary to that now being conducted by the United States Bureau of Entomology, the intention being to study these insects over the whole range of their distribution in North America. The value of such co-operative inquiry is obvious to all. In addition Mr. Criddle is investigating the insects affecting cereals and the results of his studies of the Hessian fly and the wheat-stem sawfly have been recently published.

The prairie region is also served by a laboratory at Lethbridge in southern Alberta where Mr. E. H. Strickland has been devoting particular attention to a study of the various species of cutworms which are seriously injurious to grain and other crops periodically. For example, in 1912 *Porosagrotis orthogonia* destroyed about 35,000 acres of wheat. Last year the Army Cutworm (*Chorizagrotis auxiliaris*) was studied and control measures were demonstrated in the field with valuable results. Mr. Strickland has also been investigating the abundant nematode fauna associated with growing grain.

The headquarters for our work in British Columbia are at Agassiz in the lower valley of the Frazer River. Mr. R. C. Treherne, the officer in charge, has been investigating both fruit insects and insects affecting vegetable crops. The results of his study of the strawberry root weevil (*Otiorynchus ovatus*) were published some time ago and his investigations on the cabbage root maggots are now completed. In addition he has made valuable observations as a base for further study, on the wheat midge (*Diplosis ? tritici*) and the budmoth of apple and other apple insects.

At Vancouver, B. C., we have a laboratory for forest insect investigations. Mr. R. N. Chrystal, the field officer in charge, has been studying in particular the insects destroying conifers in Stanley Park, especially species of *Chermes* and one or two lepidopterous larvæ. Under the direction of Mr. Swaine he has continued the latter's observations on the *Scolytidæ* and other timber destroying beetles in the province.

All the work is directed from Ottawa where the offices of the Entomological Branch are situated. Mr. Arthur Gibson is Chief Assistant Entomologist and in addition to assisting in the regular executive work of the Branch and the administration of the provisions of the Destructive Insect and Pest Act, he has charge of the work on insects affecting field crops, garden and greenhouse and stored products. Mr. Gibson's work on the Noctuidae is well known and during the last few years he has been investigating chiefly the control of locusts and root maggots. Mr. J. M. Swaine is Assistant Entomologist in charge of Forest Insect Investigations. The extensive coniferous forests of Canada naturally offer great opportunities for such investigatory work and particular attention has been paid to serious and widespread injuries by Scolytid beetles in British Columbia. For a number of years Mr. Swaine has been making taxonomic and biological studies of the *Scolytidae* and we hope to commence the publication of the results of this study shortly. Our studies of the spruce budworm, exclusive of its natural control, have been completed and in addition much ground work has been accomplished in the study of insects affecting shade trees. Mr. Germain Beaulieu has charge of the collections and the recent establishment of a national collection of insects has enabled us to give this aspect of our work the recognition it deserves.

The Dominion work of preventing the introduction and spread of injurious insects is carried on under the Destructive Insect and Pest Act, 1910. Under the Regulations of this Act the importation of all nursery stock, etc., is governed. Nursery stock may be imported only during certain periods through prescribed ports of entry at which fumigation and inspection stations are provided. Importers are required to give notice of the ordering and receipt of those classes of trees and plants subject to inspection. Quarantine regulations also prohibit

the importation of certain classes of nursery stock and vegetable products, for example, the importation of conifers and evergreens from the New England States is prohibited on account of the gipsy moth, of potatoes from California on account of the potato tuber moth (*Phthorimaea operculella*), of non-canned fruit from the Hawaiian Islands on account of the Mediterranean fruit fly (*Ceratitis capitata*). The field work against the brown-tail moth in Nova Scotia and New Brunswick is also carried out under the regulations of this Act. Each winter the whole of the infested area in these two provinces is scouted and all the winter webs of the brown-tail moth are collected. This careful work has so far prevented the establishment of this insect in New Brunswick and has kept it from increasing beyond harmless proportions in Nova Scotia.

It would exceed the limits which must necessarily be set to an account of this nature if I permitted my enthusiasm to exceed my judgment and described further aspects of our work which are reported annually, although I am aware of the humiliating fate that annual reports not infrequently suffer.

Mention should be made of the valuable investigations that are being carried on at Agassiz, B. C., by Dr. Seymour Hadwen, Assistant Pathologist of the Health of Animals Branch of the Dominion Department of Agriculture, on the life histories of *Hypoderma bovis* and *H. lineata*, which are undoubtedly the most important hitherto carried out.

In certain of the provinces applied entomology has made encouraging progress, particularly during the last few years. In Ontario, in which province applied entomology in Canada had its birth, the Entomological Department of the Ontario Agricultural College at Guelph has always combined with its educational work the duty of assisting the farmers and fruit growers of the province in solving their problems and with this work and the earlier work in Canada the name of Dr. C. J. S. Bethune will always be associated. In 1912, Mr. Lawson Caesar, who is Associate Professor of Entomology in the Agricultural College, was appointed Provincial Entomologist. In addition to the investigatory work on insects affecting fruit, Prof. Caesar has charge of the inspection of nurseries in Ontario, which work is carried out under the provincial Fruit Pest Act.

British Columbia at present has no Provincial Entomologist owing to the removal of Mr. W. H. Brittain, the occupant of that position for one year, to Nova Scotia. Mr. Thomas Cunningham, the Provincial Inspector of Fruit Pests has charge of the work involved in administering the regulations of the Provincial Horticultural Board governing the control of insect pests and plant diseases. It is largely due to his zeal that the province is so remarkably free from such orchard pests as the San Jose scale and codling moth. The inspection of foreign nursery stock is carried out by a co-operative arrangement with the Dominion Department of Agriculture.

The Province of Nova Scotia appointed a Provincial Entomologist in 1912, Dr. R. Matheson being the first officer. He was succeeded in 1913 by Prof. W. H. Brittain, who is also Professor of Entomology in the provincial Agricultural College at Truro, N. S. In addition to administering the provincial Injurious Insect and Pest Act, and his teaching duties, Prof. Brittain has found time to initiate several important entomological inquiries. In particular may be mentioned investigations on the aphids affecting apple, the apple maggot and *Lygus invitus*. For the purpose of prosecuting this work two provincial field laboratories have been provided, one at Kentville N. S., and the other at Smith's Cove, N. S. All nursery stock entering the province is inspected and fumigated and the Dominion Department of Agriculture has agreed to the inspection and fumigation by the province of foreign nursery stock.

Since the establishment in the province of Quebec of the Macdonald Agricultural College at St. Annes in 1907, Prof. W. Lochhead and his staff have developed the study and practice of applied entomology in the province and at the present time entomological investigations are being conducted there. Much educational work is being accomplished through the Quebec Society for the Protection of Plants from Insect Pests and Fungous Diseases which receives a provincial grant. In 1912 the Abbe V. A. Huard, Curator of the Provincial Museum at Quebec, was appointed Provincial Entomologist and he administers a provincial act passed in 1913, providing for the inspection of nurseries in the province.

In the other provinces of Canada, no provincial entomologists have been appointed and where entomological investigations are being conducted they are in connection with one

or other of the Dominion Field Laboratories that I have mentioned. As the need for more work, particularly of a local character, develops, additional attention will no doubt be paid by the Provincial Departments of Agriculture to applied entomology. In the meantime they rely on the assistance provided by the Dominion Government. Where Dominion and provincial officers are carrying on investigations in the same province, the heartiest co-operation is enjoyed and arrangements are made with a view to preventing duplication of the work and consequent loss of energy. In certain cases investigations are conducted conjointly and this spirit of co-operation is most valuable, particularly in its relation to the attitude of the public towards the work.

CEYLON.

For a number of years Mr. E. E. Green, who is widely known by his work on the Scale Insects, was Government Entomologist to the Department of Agriculture of Ceylon and subsequent to his relinquishing the position in 1911, entomological work on this island was carried on by Mr. A. Rutherford whose recent untimely death was a great loss to colonial entomology. Mr. E. R. Speyer is now in Ceylon investigating the most serious insect pest of the island, namely, the shot-hole borer of tea *Xyleborus fornicatus*. Tea is also injured by the tea Tortrix, *Capua coffearia*, the yellow tea mite, *Tarsonemus translucens*, and the Termite, *Calotermes militaris*, which hollows out the stems of living tea bushes. Rubber in Ceylon is attacked by a number of insects, particularly root and other borers. Cocoa, rice and mulberry plants are subject to the attacks of a number of pests. Various species of Termites are injurious to woodwork as in most tropical countries where they occur.

FIJI.

When Mr. F. P. Jepson commenced his work as Entomologist to the Department of Agriculture of Fiji in 1909, he found serious problems awaiting his attention, particularly in the matter of insects affecting bananas and cocoanuts. On the island of Viti Levu cocoanut cultivation was practically abandoned many years ago, owing to the injury done to the leaves by a small moth *Levuana iridescens* B. B. Since 1912 a change

has taken place which renders the chances of combatting the insect successfully more hopeful. The most serious pest of the bananas in Fiji is the weevil *Cosmopolites sordidus* Germ.; as many as 100,000 individuals having been collected in one month on a single plantation. This widely distributed pest was introduced in 1901. As enemies in the form of predacious beetle larva occur in Java and Dutch Borneo, and in view of the impossibility of controlling the pest by artificial means, Mr. Jepson visited Java in 1913 to study the insect predators of this weevil and among them he found the Histerid beetle, *Plæsius javanus* Er., the most effective. Five thousand of these beetles were collected and three thousand seven hundred and ninety-two were successfully transported to Fiji where they were distributed in lots of 500 upon different badly infested banana plantations. Subsequent visits showed that the beetles were alive and reproducing after four months in the country and good results are expected from this interesting experiment, which indicates the progressive character of Mr. Jepson's work.

India.

The control of insect pests in India is a subject of singular interest, not so much on account of the unusual nature of the insects which are encountered there but owing chiefly to the character of the cultivators, the nature of the country and the climatic conditions. Agriculture constitutes at present the chief industry of the country and about sixty-five per cent. of the people are dependent upon it as a means of livelihood. The European planter is practically negligible as a constituent factor, the dominant class being the cultivators. These are native Indians who live on the land and have had a very limited education. In many cases they have inherited a perfect system of agriculture. But in the face of an insect outbreak their preconceived notions of such calamities, their aversion to taking life directly and their lack of any kind of material equipment for fighting pests make the application of modern methods of insect control almost an impossibility. Prof. Maxwell Lefroy who did valuable work of a fundamental character in India, has described some of the prevalent ideas, he says: "An intelligent cultivator growing sugar-cane under irrigation on an extremely sound system with good manure, believes the cane-borer comes with the well-water used for irrigation." He has no conception

of its life history but he regards the whole thing as a mystery, not comparable with the life of any other animal; he will, as likely as not, call in a priest to check it; the priest will perhaps write four texts from holy writings, place them one at each corner of the field to confine the evil influence and then remove one to let out the influence which the texts have incommoded. Or, he will pay a man of a certain caste to plough a line across the field at night, the man having to be stark naked. In some parts locusts are believed to be the incarnation of a particular deity and for each one killed a hundred will come; it is quite likely that this has occurred, of which a few were killed being followed later by a much larger swarm, but where we see no connection, he sees a definite sequence of events. A case came up where a man freed his rice field of a pest by a simple mechanical method; his crop benefited but soon after his cow died, and to that village the one was a consequence of the other. It is difficult for entomologists in countries such as ours to realize the almost impossible task of overcoming such long inherited and deeply ingrained instincts and religious beliefs. These facts should be borne in mind in studying the methods employed. The use of insecticides is naturally enormously restricted as also is the employment of any but the simplest of mechanical devices. Largely for these reasons we find the necessity of resorting to such methods as the use of bait traps for moths and hand picking, the latter being rendered possible by the cheapness of the labor.

The losses from insects in so large a country are naturally great and in many instances the failure to grow staple crops in certain regions is undoubtedly due to an inherited tradition, resulting from uncontrolled insect outbreaks, that such crops cannot be grown. An outbreak of the cotton boll worm in the Punjab and Sind in 1906–07 caused a loss of about 2,000,000 pounds sterling. In the locust campaign of 1903–04, 14,000 pounds sterling was spent in destroying these insects in one province. The great Kirman Desert of Persia constitutes the chief central breeding place for the parent flights of *S. peregrinum*, entering India from the northwest.

In order to understand the organization of the work in applied entomology it is necessary to know the system of government. The government of India is the supreme authority,

the provinces into which the country is divided being under provincial departments such as Madras, Bombay, Central Province, Bengal, etc. The Imperial Department of Agriculture conducts investigations and advises and directs the work of the provincial departments. The latter largely carry into effect the recommendations of the Imperial experts as they do not all employ experts of their own, although a number of them now have native or European entomologists attached to their agricultural staffs.

The headquarters of the Imperial Entomologist are at the Imperial Research Laboratories at Pusa. Mr. T. Bainbrigge Fletcher is Imperial Entomologist and Mr. T. M. Howlett has charge of the work in medical and veterinary entomology. In addition to English assistants there is an excellent native staff. The scope of the work includes the investigation of the life histories and bionomics of insect pests and the most practicable methods of control under local conditions and experimental work with insecticides.

An important section of the entomological work has reference to useful or productive insects particularly sericulture and the production of lac. These constitute important industries in certain sections of India. For example, about three million pounds worth of lac is produced annually and whereas at present it is mainly a forest product, collected wild in the jungles, the entomologists have shown how it can be produced more cheaply by proper cultivation on trees growing on pastures and waste lands in agricultural tracts. Prof. Lefroy's work on Eri silk, produced by *Attacus ricini* of Assam, furnished a means whereby a new silk industry might be built up in certain localities in India.

Among the more important pests the following may be mentioned:

In certain regions swarms of hairy caterpillars, the larvæ of Arctiid moths, appear regularly after the first rain and cause great loss in grass lands, etc. It has been found that these insects can be largely controlled by capturing the adult moths in bait traps of the Andres-Maire pattern. In one region in Bengal about 10,000 acres of Tal land was destroyed annually for fifteen years by caterpillars of *Agrotis ypsilon*. It was found that hand picking of the larvæ and capture of the

moths by bait traps constituted the best control measures. In the bait traps eighty per cent. of the moths were unfertilized females. Serious damage to the rice crop is caused by the rice grasshopper (*Hieroglyphus furcifer*). For the control of this insect coarse bags are used, the bags being kept open by two bamboos as they are drawn through the rice which of course is grown in water; two beaters go before the bag and drive the grasshoppers towards or with it. Cotton is attacked by two boll-worms and a *Gelechia;* the boll-worm is a serious bar to the growth in India of any but the short stapled cottons which mature rapidly and offer little scope for boll-worm injury. In the control of the boll-worm in the Punjab, success appears to have attended the use of parasites.

The immense loss of life due to insect-borne diseases, especially to malaria in India is well known and the importance of the work carried out by Mr. Howlett in conjunction with the Imperial Medical and Veterinary Departments needs no emphasizing. Entomologists and medical men in India have had no small share in the advancement of our knowledge of medical entomology from the time when Ross carried out his crucial investigations up to the present time and the standard and scope of the work in India is steadily increasing year by year through the labors of men such as Dr. W. S. Patton, F. W. Cragg and others.

The condition of India in regard to that problem, which is of such vital concern to more temperate regions and regions in which agricultural development is taking place, such as the United States and Canada, namely, the introduction and establishment of foreign insect pests is peculiar and full of interest from a biological standpoint. The fact that India has not taken in years past any special steps to prevent the introduction of insect pests may appear strange to the minds of many accustomed to the necessity of such measures. The omission is not due to a failure to appreciate the importance of foreign pests, but to a distinct failure on the part of foreign pests to become acclimatised to Indian conditions. India appears to be protected far more effectively, and at considerably less cost, against foreign insect pests by her climate and topographical features. It is an isolated country bounded on the north by a vast non-agricultural territory from which it is separated by a

formidable mountain barrier. Prof. Lefroy informs us that in India fierce dry heat is the insect's enemy and the greatest check on insect life is that period before the rains when all is parched and very hot. These are powerful adverse factors to most foreign insects, although some, such as the cabbage white (*Pieris brassicæ*) and the wheat aphis (*Toxoptera graminum*) have adapted themselves in different ways to the climatic conditions. A statement which Prof. Lefroy has given of the relative proportions of native and introduced insects indicates very clearly the evident check on the ability of foreign insects to become acclimatised to India. Of the crop pests, exclusive of scale insects and mealy bugs, out of 213 species injurious in some degree, two moths and six aphides are possible introductions. Out of 109 scale insects, 24 are probably introduced and of the most injurious ones, eleven out of the fourteen, are introduced; the introduced scale insects are comparatively harmless as a rule in India. These facts afford an interesting contrast to our experience in North America.

New Zealand.

The chief agricultural industry in New Zealand has been sheep farming. But with development along other lines, particularly in horticulture, the country has suffered the fate of all new countries dependent upon the importation of plants from foreign countries, and foreign pests have been introduced. At first these pests were not subjected to the methods that a later developed intensive system of agriculture involves and consequently they made some headway.

While the entomological work of the government is largely undertaken by the Government Biologist, Prof. T. W. Kirk, the question of the control of insect pests is also dealt with by the Fields and Experimental Farms Division and by the Orchards, Garden and Apiaries Division. The latter Division administers the inspection laws, involving the fumigation and inspection of imported fruits and plants and the spreading of useful insects. The Biological Section of the Department of Agriculture investigates, so far as its other duties permit, injurious insects in addition to conducting general identification work.

British West Indies.

In 1898 the Imperial Department of Agriculture for the West Indies was established with headquarters at Barbados for the purpose of rendering assistance in agricultural matters throughout the British West Indies, including British Guiana, Trinidad, Jamaica, British Honduras, Bahamas, Bermuda, Barbados, the Windward Islands and the Leeward Islands. It is principally concerned, however, with the smaller islands, namely, those of the Windward and Leeward groups and Barbados. As the larger colonies British Guiana, Trinidad and Jamaica have organized departments of agriculture and being in a more prosperous condition, it is the function of the Imperial Department to advise the Government of these colonies. In the case of British Honduras, Bahamas and Bermuda, advice by correspondence is fully available.

Mr. H. A. Ballou succeeded Mr. H. M. Lefroy in 1903 as Entomologist on the staff of the Imperial Department and he carries on his work under the direction of the Commissioner of Agriculture, Dr. Francis Watts. In addition to the entomological work conducted by the Imperial Department, certain of the West Indian colonies maintain entomologists or combine the work with that on plant diseases. Mr. F. W. Urich is Entomologist to the Board of Agriculture for Trinidad and Tobago; Mr. G. E. Bodkin, as Economic Entomologist to the Department of Science and Agriculture of British Guiana, is responsible for the entomological work in that colony. Mr. A. H. Ritchie was appointed about a year ago as Entomologist to the Department of Agriculture for Jamaica. In Barbados the entomological work of the island is carried on by Mr. J. S. Dash, the Assistant Superintendent of the local Department of Agriculture, for although the Imperial Department of Agriculture has its headquarters in Barbados it has no direct connection with the agriculture of the colony.

The Entomologist of the Imperial Department of Agriculture Mr. Ballou, is directly concerned with the insect problems of the Windward Islands (Grenada, St. Vincent and St. Lucia) and the Leeward Islands (Dominica, Montserrat, Antigua, St. Kitts-Nevis and the Virgin Islands). He has a laboratory in the departmental building and on each island facilities for field work are provided by the local agricultural departments, each

of which has a botanic garden or experiment station, and the officers in charge of these gardens or stations assist in the local entomological work.

The chief lines of entomological investiagtion are associated with the principal crops grown on the islands, namely, sugar cane, cotton, cacao, limes and cocoanuts. A large number of new crops are being tried and these will naturally introduce new lines of entomological inquiry. The islands have suffered the fate of all new regions into which new crops have been introduced. The crops grown at present are practically the same as they were ten years ago, the principal difference being the standing of the cotton industry which was then in an experimental stage. Now it has been established as a profitable industry and as a result of the rapid increase in the acreage of cotton, insects which previously were not recognized as pests, and in some cases were unknown to science, have assumed an important role as serious pests. For example, the flower-bud maggot of cotton (*Contarinia gossypii* Felt) first made its appearance in Antigua in 1907; the leaf blister mite *Eriophyes gossypii* Banks, first occurred as a pest of cultivated cotton in Montserrat in 1903 and soon afterwards was found in all the other islands of the Leeward and Windward groups. The black scale (*Saissetia nigra* Nietn.) was formerly a serious pest of cotton, but at present it attracts little attention owing to the control brought about by the parasite (*Zalophothrix mirum*) which was first reared in 1907. Important injuries are caused by certain hemipterous cotton stainers of the genus *Dysdercus*, and a serious internal boll disease or rot now under investigation, occurring in certain islands appears to be associated with the attacks of these cotton stainers.

One of the most serious classes of injurious insects occurring in the West Indies, particularly in fields of sugar cane and corn (maize), are the Melolonthid larvæ known as white grubs on this Continent; these insects are popularly known as hard backs on the islands, the chief species being *Ligyrus tumulosus*. On certain of the islands recent investigation has shown that a noticeable control is exercised by several insect parasites of these larvæ. Among the control measures recommended are the planting of trap crops and hand picking the larvæ which measure cheap juvenile labor renders possible. Lepidopterous

and rhyncophorous borers, particularly such root borers as *Diaprepes abbreviatus* L. and *Exophthalmus esuriens* are serious pests of sugar cane. Termites are also injurious to sugar cane.

Citrus trees in the West Indies have their full share of scale insects, the purple scale (*Lepidosaphes beckii* Newm.) being the most important. A considerable degree of control is exercised over this and other scale insects by certain entomophagous fungi. The red-headed fungus (*Sphærostilbe coccophila*) and the white headed fungus (*Ophionectria coccicola*) attack the purple scale, the former fungus also attacks the white fly (*Aleyrodes citri* R. and H.) The green scale (*Coccus viridis* Green) is controlled to a marked degree by the shield scale fungus (*Cephalosporium lecanii*). In Trinidad the fungus *Metarrhizium anisoplæ* has been artificially cultivated and used with a view to controlling frog-hoppers attacking sugar cane.

Naturally every effort is made to prevent the introduction of foreign pests into the islands by quarantine regulations. The regulations of the various plant quarantine acts are carried out by the local agricultural officers in the various islands; these officers are required to inspect plant imports and to arrange for the necessary fumigation and other prescribed treatment.

Much of the entomologist's time is occupied in traveling, owing to the geographical situation of the islands of the Lesser Antilles and the difficulties of steamboat travel which result in an unfortunate loss of time. Nevertheless, the pages of the *West Indian Bulletin*, the quarterly journal of the Imperial Department of Agriculture and its fortnightly publication, *The Agricultural News*, and the pamphlets that have been issued dealing with the insect pests of various crops bear witness to the excellent work that is accomplished by the Entomologist in spite of the difficulties with which he has to contend. And the same may be said of those who are responsible for entomological work in the individual West Indian colonies that I have mentioned.

Other Imperial Entomological Work.

Space forbids an individual treatment of the entomological work that is being carried out in scattered units of the British Empire to which reference has not been made. In many of these places the investigations that are being conducted relate

chiefly to insects and ticks concerned in the transmission of disease such as those of Dr. W. M. Aders on ticks in Zanzibar. In the Seychelles entomological observations are being made by Mr. P. R. Dupont, the Curator of the Botanical Station; in the Federated Malay States Mr. C. Strickland is studying mosquitoes and malaria, and other entomological work, particularly on locusts, is also being carried on by Mr. C. B. Holman Hunt and Mr. P. B. Richards. M. D'Emmerez de Charmony is paying attention to the insects of Mauritius, and in Cyprus the entomological work is conducted by Mr. Z. G. Solomides, who is called upon to deal with the locust plagues to which this island is subject.

THE THORACIC AND CERVICAL SCLERITES OF INSECTS.

By J. F. MARTIN.*

CONTENTS.

INTRODUCTION.

This paper is presented as the morphological part of a thesis for the degree of Doctor of Philosophy at the Massachusetts Agricultural College. It has been prepared under the supervision of Dr. H. T. Fernald and Dr. G. C. Crampton, to both of whom I wish to express my sincere thanks for the many ways in which they have guided and helped me in the work. I am also indebted to Dr. G. C. Crampton who has kindly furnished all the material upon which this paper is based and by which it was made possible.

Some of the literature used and referred to was obtained from the library of the Massachusetts Agricultural College. Other volumes were obtained from the Boston Society of Natural History, through Dr. H. T. Fernald. Most of the books, however, were loaned from the private libraries of Dr. C. H. Fernald, Dr. H. T. Fernald, and Dr. G. C. Crampton, to each of whom I am greatly indebted for their use.

*Contribution from the Entomological Laboratory of the Massachusetts Agricultural College.

The homologies of the thoracic sclerites have been greatly confused, owing to the fact that most investigators have given their own views, without first giving sufficient study to the work and terminology of previous writers. This has resulted in the invention of new terms and the misapplication of those already in use. Both the old and new terms have often been applied to identical sclerites and consequently the terminology is also in a chaotic condition.

Some of the more recent writers have attempted to show the unity of thoracic structure, which exists in all insects and to introduce a terminology which will be as uniform as possible. This is a very difficult task to accomplish because of the great confusion which exists.

In this paper an attempt is made to help straighten out the homologies and terminology of the thoracic sclerites of insects. An effort has been made as far as possible, to use the terminology most widely accepted and which has the right of priority. Where recent terms have been applied to sclerites, for which the old terms seem inadequate or undesirable, the new terms have been adopted. In some cases entirely new terms have been applied to sclerites, but only where the condition of the terminology seemed to warrant such action and where, in the opinion of the writer, an improvement could be made.

Especial attention has been given to a study of the pleuron and sternum. The tergum and wings have not been investigated so thoroughly and consequently a discussion of these parts is not given in detail. All the specimens were studied under a liquid medium (water, alcohol or glycerine), with the aid of a Zeiss binocular microscope. A bull's eye condenser was used to concentrate the rays of an electric light upon the object under study. In many cases the specimens were first boiled in 10% potassium hydroxide. The internal tissues were then washed out with running water, thereby making the sclerites show up clearly and leaving the internal processes intact. This procedure greatly facilitated the determination of the thoracic sclerites and their sutures.

HISTORICAL REVIEW.

Several theories have been proposed to explain the probable formation of the thoracic segments and almost every writer seems to have a different view of the subject. This has led to the formulation of many different theories, some of which are merely the unsupported statements of their respective authors, who have failed to give reasons for their views. Such theories apparently have no evidence to support their presentation and hence cannot be accepted, especially when other writers have advanced differing theories established upon firmer grounds. Some investigators have based their ideas of the thorax upon the study of a limited number of insects, whereas they should have studied at least a representative number from different groups, in order to obtain a general conception of the thorax. Others who have studied a large number of insects have failed to recognize the relation that exists between the thoracic sclerites. This has given rise to incorrect interpretations of the formation of the thorax and to great confusion in the homologies of the thoracic sclerites in the same and in different insects.

The earlier entomologists wrote very little about the insect thorax. Knoch, 1801, termed the prothorax "Collum" and the meso-, and metathorax, "Pectus." He may have recognized that the thorax was composed of three segments, which are topographically grouped into two parts, the collum and pectus, or he may have considered that the thorax was actually composed of only two segments, viz.: the collum and pectus.

Chabrier, '20, Kirby, '28, and later Verhoeff, '02–'04, although aware that the thorax was composed of at least three segments, thought that it might be divided according to function into two parts. These two parts were termed by Chabrier, the collier and tronc alifere; by Kirby, the manitruncus and alitruncus; and by Verhoeff, the proterothorax and deuterothorax. This idea is no longer accepted.

Audouin, '24, upon whose investigations the modern conception of the thorax is based, points out that it is composed of three simple segments and was the first to work out a terminology for the thoracic sclerites, which has been used by all subsequent entomologists. Beginning with the anterior thoracic segment, he named them the pro-, meso-, and metathorax,

terms which seem to have been first used by Nitzsch, '18, although Nitzsch called the first segment the protothorax instead of prothorax. Audoiun regarded each thoracic segment as made up of four parts; a dorsal region, the tergum; a ventral region, the sternum; and two lateral regions, the pleuræ. He thought that the tergum was composed of four transverse subdivisions, lying one behind the other in consecutive order. Beginning with the anterior one, he termed these the prescutum, scutum, scutellum and postscutellum. The sternum he regarded as a single piece. For each lateral region or pleura he described and named several pieces, viz.: two large lateral sclerites, the anterior one termed the episternum and the posterior one the epimeron; a small narrow piece lying along the anterior edge of the episternum termed "paraptere," (previously called "hypotere" by Audouin, '20); a small sclerite containing the spiracle termed the peritreme and a sclerite articulating with the epimeron termed the trochantin.

Audouin was mistaken in his definition of the last mentioned sclerite, because the trochantin articulates with the episternum, not with the epimeron. Later Audouin, '32, defined the "paraptere" as "the small piece so visible in Hymenoptera and Lepidoptera, which covers the base of the fore wings and which is variously designated by the terms ecaille, epaullette or squamula." (Audouin's trans. of Mac Leay's paper, "The comparative anatomy of the thorax in winged insects, following a review of the actual state of the Nomenclature." pp. 41, footnote by Audouin). According to this statement the "paraptere" is evidently synonymous with tegula.

Subsequent entomologists in applying this terminology for the thoracic sclerites have misinterpreted the homologies and consequently confused the names. Several sclerites, which Audouin apparently failed to recognize, have since been described. In descriptions of these, different investigators have invented new terms for identical sclerites, leading to more confusion.

In all insects there is a common ground plan, which is more modified in some, less so in others. On this basis recent writers have attempted to work out a uniform system of terminology applicable to all insects. In order to do this, it is first necessary to correctly homologize the sclerites in the

different orders of insects and then to straighten out the confused terminology which has been applied to them—an almost impossible task.

Straus-Durckheim, '28, believed that the thorax was composed of three segments and suggested that the cervical sclerites represent the remains of two segments, situated originally between the head and prothorax. This suggestion will be discussed under the heading, Cervical Sclerites.

Mac Leay, '30, considered that each thoracic segment was made up of four subsegments or annuli, represented in the tergum by the prescutum, scutum, scutellum and postscutellum. In the Zoological Jour. 1830, Vol. 5, pp. 160, he states that "owing to the development of the tergum, the pectus in Hymenoptera is exceedingly diminished. But were each of the sternums at its maximum of development, it would also be found to consist of four pieces like a tergum. This is the case in Julidae and is more or less apparent in Annulosa. For instance, the pectus of the prothorax in *Squilla* has a praesternum, sternum, sternellum and poststernum." Mac Leay leaves the pleuron out of consideration. According to modern ideas his view of the tergum is erroneous, since the tergum is made up of but two plates, as Verhoeff, '02, Snodgrass, '09, and others have proved. The anterior of these two plates is subdivided into regions by sutures, these regions being termed the prescutum, scutum and scutellum. The posterior plate is termed the postscutellum. Since Mac Leay claims that the four sternal plates described by him occur in the pectus of the Julidæ, which are diplopods, and in *Squilla*, which is a crustacean, his theory is not at all necessarily applicable to insects.

Newport, '39, evidently agreed with Mac Leay regarding the formation of the thoracic segments. He thought that each was made up of four subsegments or annuli, represented in the tergum by the prescutum, scutum, scutellum and postscutellum. These annuli, he thinks are partly fused in the pleural region and completely fused in the sternal region. Newport added nothing new to this theory of Mac Leay's and it must be regarded as untenable. Newport, however, brought forth a new view pertaining to the cervical sclerites, which will be referred to later. Furthermore, he is incorrect in his statement that Audouin considered each thoracic segment to be

composed of four subsegments, for, as already stated, Audouin appears to have believed that the thorax consisted of three simple segments.

Schiodte, '56 and Winslow, '62, followed Audouin's ideas and believed that the thorax was composed of but three segments, the pro-, meso-, and metathorax.

Packard, '80, seems to have regarded the thorax as made up of three simple segments, but his interpretations and methods of homologizing the thoracic sclerites in the insects of the different orders which he studied, are incorrect. The homologies of the thoracic sclerites will be discussed further on.

Miall and Denny, '86, in their book on the Cockroach, considered that the thorax was composed of three segments and suggested that the chitinous plates at the base of each leg in the roach (i. e. epimeron, episternum, trochantin, etc.) represent "two basal leg joints, which have become adherent to the thorax," although in other cases they state that they belong "to the thorax and not to the leg."

If these sclerites at the base of the leg in the roach represent leg "joints," there would probably be more definite traces of these joints in other insects, especially as the leg is such an important appendage. In the embryo of the cockroach the coxa is apparently the only basal leg segment present and there are no indications of other leg segments which have or which might become adherent to the thorax. This is true for other insects as well as for larvae and primitive forms. Moreover, it is improbable that such leg segments, if present, would form the lateral wall of the segment or pleuron which Miall and Denny thought was the case in the Mole Cricket. It seems more probable that the basal leg "joints" or segments would remain in place and not move up into the pleural region. Börner considered the pleural plates as part of the sternum, but later with Henneguy, thought that they were plates of the basal leg segments.

Hagen, '89, advanced the theory that each thoracic segment was composed of three subsegments, each subsegment bearing a characteristic appendage. The anterior he terms the leg bearing, the next following the wing bearing, and the posterior, the spiracle bearing subsegment. Some of the subsegments develope more than others. On the prothorax of Strepsiptera and agrionids, he finds traces of "wings."

The spiracle does not occur in all the thoracic segments, being absent in some cases. Whether the spiracles which often occur between the thoracic segments belong to the immediate anterior or to the immediate posterior segment, is uncertain and at present a disputed question. What Hagen considered rudiments of wings on the prothorax of Strepsiptera and agrionids, have proved to be merely flaps and are no longer considered homologous with wings. Several fossil Palaeodictyoptera have a pair of lateral wing-like appendages on the prothorax, like rudimentary organs, but it is very uncertain whether these appendages do or do not represent traces of wings.

Patten, '90, claims that each thoracic segment is composed of two annuli. Using the nervous system of *Scolopendra* as a type, he found in all arthropods studied, two cross commissures in each neuromere, thus indicating the double nature of these structures. In *Acilius* the median furrow between the cross commissures was similar to that found between the successive neuromeres. In *Scorpio*, the neuromeres are distinctly double and in such forms as *Julus*, the cardiac ostia, arteries, tracheæ and legs show the double nature of the somites. Segmental fusion is also indicated by two pairs of tracheal invaginations in each segment of *Acilius*, by the bifurcated appendages of many crustacea and by the bifid maxillæ of insects, the latter group frequently having monsters with double pairs of legs.

Patten's double segment theory based upon the reasons cited above, does not coincide with the facts in all cases, and hence is open to objections. Furthermore, what occurs in *Scolopendra* should not be given too much weight, when considering the condition found in insects. In insects the last abdominal segment is considered as the fusion product of several neuromeres and yet it contains only two cross commissures, whereas according to Patten's idea, there should be as many commissures present as neuromeres. In Vermes the neuromeres of each segment contain but two cross commissures, although the segments are not double. The median furrow between the cross commissures in *Acilius*, if there is a furrow, which is doubtful, can hardly be similar to that between the successive neuromeres, for the latter are separated by a considerable distance. In such forms as *Julus*, Patten found the double nature

of the somites indicated by the cardica ostia, arteries, tracheæ and legs, but this does not prove the double nature of the somites in insects. Embryologists in general, seem to have never found two pairs of tracheal invaginations in any one segment in insects. Patten's second pair of tracheal invaginations in *Acilius* has proved to be a mass of cells, easily mistaken for tracheal invaginations. Monsters with double appendages occur throughout the animal kingdom very frequently and are generally considered as abnormalities; not as a reversion to primitive types or conditions.

Lowne, '90, favors the compound segment theory of Patten, but thinks that it has not been sufficiently proved.

Banks, '93, in studying the chilopods observed a coalescence of the thoracic segments, less apparent in the lower forms (*Geophilus*) than in the higher ones (*Scutigera*) and from this concluded that the thorax of insects is composed of five segments, the first, third and fifth bearing legs, the second and fourth bearing wings. He points out in support of this theory that *Machilis* has a pair of small rudimentary appendages on each abdominal segment, which are also found on the meso- and metathorax in addition to the legs. From this, he argues, that the rudimentary appendages represent legs and hence, that the meso- and metathorax are compound segments.

These rudimentary appendages found in *Machilis* occur in other insects, also in Myriopoda and are the so-called styli—not vestigial legs. Jourdain, '88, considered these styli as homologous with the exopodite of Crustacea. Haase, '89, regarded them as modified setæ. Henneguy, '04, homologizes the styli with the epipodite of the crustacean leg and Verhoeff, '04, compares them to the coxal organs of Myriopoda. At present, however, it is not known exactly what the styli are, but they certainly are not regarded as vestigial legs by modern investigators. Banks' theory has no embryological support and furthermore, what occurs in chilopods is not necessarily any criterion of what occurs in insects.

Kolbe, '93, considers that the thorax is composed of three primary segments between which, he finds marked off, other "complementary segments," in such forms as the larvæ of *Lampyris* and *Raphidia*, also in *Locusta*, *Oedipoda*, etc. His conclusions are based principally on the larvæ of *Lampyris* and

Raphidia and he was the first to suggest the possibility of the occurrence of intersegmental or "complementary segments." This is not supported by embryology, however, which gives no indication of "complementary segments." Larvæ frequently acquire secondary adaptative structures, which cannot be considered as a retention of the primitive condition and the "complementary segments" of the above mentioned larvæ are probably some such secondarily acquired structures. Kolbe's theory needs more proof to support it than the presence of secondarily marked off regions in larvæ. A dissection of the larva of a beetle in which there are present "complementary segments" identical with those described by Kolbe in the larva of *Lampyris* demonstrates the following facts: that the "complementary segments" have no segmental muscles or other segmental structures; that the "complementary segment" is apparently a fold of the sternal integument and does not extend to the tergum; that it belongs to the segment in front of it and that each actual segment is marked off by an internal ridge, which extends completely around the body and has longitudinal segmental muscles connecting one ridge with the next. These three ridges probably define the three thoracic segments.

Walton, '00, is the exponent of another double subsegment theory which is similar to Banks'. He considers the coxa in the Hexapoda and Chilopoda as the fusion product of the appendages of two primary metameres which he terms, "coxa genuina" and "meron." The meron represents the rudimentary appendage of the posterior metamere, which articulates with the epimeron, and the "coxa genuina" represents the basal leg segment of the functional appendage of the anterior metamere, which articulates with the episternum and has persisted. From this he concludes that each segment is composed of two metameres. Walton's idea that the meron represents a vestigial leg is as improbable as Banks' view, that the styli of *Machilis* were the vestiges of legs. There is no embryological evidence to support Walton's theory and he has since repudiated it.

Comstock and Kochi, '02, think each thoracic segment is composed of two subsegments, which have become fused together. The line of division between them is represented in the tergum by the suture between the scutum and scutellum, in the pleuron by the pleural suture and in the sternum by the furcæ.

This theory is open to the same objections as the other compound segment theories previously stated, viz.: that embryology gives no indications of compound thoracic segments. Primitively the episternum and epimeron appear to consist of a single plate, a portion of which has become drawn inward, probably by muscular stress, forming a hollow infolding of the integument, which is represented externally by the pleural suture and internally by the lateral apodene. The anterior sclerite formed by this infolding of the pleuron, is termed the episternum, and the posterior sclerite, the epimeron. If this explanation be true, Comstock's and Kochi's view, as well as Banks' and Walton's idea which is very similar, namely, that the pleural suture is the line of union between two subsegments, must be regarded as untenable.

Verhoeff, '02-'04, made an extensive study of the comparative morphology of the insect thorax and his conclusions are based mainly on the thorax of the Chilopoda, Apterygota, Orthoptera, Dermaptera and Embiidæ. His theory is an elaboration of the views advanced by Kolbe. In studying *Japyx*, Verhoeff found in front of the "chief segments," represented by the pro-, meso-, and metathorax, indications of three other segments, which he called complementary segments and termed them micro-, steno-, and cryptothorax respectively. Thus the thorax would consist of six primary segments viz., micro-, pro-, steno-, meso-, crypto-, and metathorax. He found, on further study, that in front of each of these six primary segments were a few small sclerites, which he considered as the remains of six other segments and termed them the intercalary segments. Hence according to Verhoeff the thorax would consist of six primary and six intercalary segments, making a total of twelve thoracic segments, or in other words, each segment of the thorax consists of four annuli. This theory has been severely criticized by several writers and now is generally considered as incorrect. Silvestri, '02, and Börner, '03, criticized Verhoeff's views and the latter shows by his figures that Verhoeff's statements are erroneous. Börner states that the thorax is composed of three segments with intersegmental regions.

Voss, '04, gives Kolbe's and Verhoeff's composite segment theory, stating four possible modifications of it, which can be

found in diplopods, *Scolopendra*, *Geophilus* and *Scolopendrella*. He thinks that the pre-segmental chitinous plates in insects are a secondary differentiation, explainable by mechanical causes as represented in lampyrid larvae.

Enderlein, '07, regarded the complementary segments in *Japyx*, which correspond to Verhoeff's micro-, steno-, and cryptothorax as "constricted-off" portions of the pro-, meso-, and metathorax and terms them the apotom of their respective segments. That is to say, they are detached portions of the pro-, meso-, and metathorax.

Desguin, '08, attacks Verhoeff's theory and shows that embryology, anatomy, musculature, etc., give no evidence in support of it. Other writers have criticized Verhoeff's ideas and it has been shown that all the facts seems to be contrary to his views. Unless further evidence is brought forth to substantiate Verhoeff's theory of the composition of the insect thorax it must be regarded as untenable.

Henneguy, '04, reverts to Kolbe's theory and expresses similar ideas. He finds in the larva of *Lampyris*, that each tergum covers two ventral "segments," the first of which bears a pair of spiracles and is known as the complementary segment, while the second segment bears a pair of legs. He finds these same conditions in *Scolopendrella* and from this concludes, first, that the Myriopoda are ancestors of insects; second, that the present position occupied by the spiracles in adult insects is explainable on the ground, that they are borne on the complementary segments. Henneguy finds traces of complementary segments in the thoracic region of elaterid and staphylinid larvae and in the abdominal region of carabid larvae. He finds that in the larva of *Raphidia*, the complementary segment between the pro-, and mesothorax, is a complete segment. The larvae of some Diptera appear to have double the number of segments present in other larvae of the same family, each complementary segment being produced by a transverse constriction of such a nature, that a sort of intermediate segment is formed between the normal segments. Henneguy states, that according to Brauer, this arrangement is due to a lengthening of the membrane uniting two consecutive segments, or to a secondary constriction of each annulus.

What has been said of Kolbe's theory will also apply to Henneguy's views. Henneguy's conclusions that Myriopoda are the ancestors of insects and that the position of the spiracle is to be explained by supposing that they were borne by the hypothetical complementary segment must have a firmer foundation before they can be accepted. Whether the spiracles belong to the segment in front of them or to the segment behind them is at present a disputed question. The spiracles are usually absent in the prothorax. It certainly seems more probable that the so-called complementary segments are parts of the pro-, meso-, and metathoracic segments, since this view is supported by embryology, anatomy, musculature, etc.

Woodworth, '06, states that "theories of composite segments in the thorax seem to be entirely untenable." He appears to consider the thoracic segment as originally made up of a solid ring, which later becomes split in the following manner. The development of the legs, results in the separation of the sternum from the remainder of the segment; in the beginning of the formation of the pleural suture; and of the suture which ultimately separates the scutum from the scutellum. The development of the wings results in the completion of the above mentioned sutures; in the development of the prescutum and postscutellum, and in the separation of the tergum from the pleuron. Hence he concludes that the wings are not the product of the pleuron or the notum, but are the means of their differentiation phylogenetically and ontogenetically.

Woodworth's conception of the thoracic segment is no longer accepted by most entomologists, although many originally held the same view. In all primitive insects and in larvae the sclerites arise as numerous islands of thickened chitin and not as a solid chitinous ring, which later becomes split up. In the more specialized insects these small sclerites become more or less fused together. This can be clearly demonstrated by studying a series of insects beginning with larval and primitive forms as *Eosentomon*, and gradually working up to the more specialized groups.

Berlese, '06, regarded each thoracic segment as originally made up of a "tergite" and "sternite." The "tergite" was one solid piece which included the "alar sclerites," the spiracles, the tergum and the epimeron. The "sternite" is composed of

four pieces which he termed the acro-, pro-, meso-, and metasternites. The acro and prosternites constitute the "sternum," while the meso- and metasternites form the "sternellum." With this as a basis Berlese accounts for the sclerites which make up a typical thoracic segment in the following manner. First, the epimeron became split off from the "tergite," while the leg appendage arose from a part of the "metasternite" and later the trochantin, consisting of two pieces became split off from the "sternellum," in the region of the coxa. Next, the epimeron entered into the composition of the pleuron near the coxa and the two "alar plates" at the base of the wings, together with the spiracles, became detached from the "tergite." The "sternum" became split up into pieces to form the episternum and sternum. It is obvious that Berlese's theory is untenable. Considered from an embryological and anatomical point of view, it has no foundation whatever.

The later writers, Crampton, '08-'09 and Snodgrass, '09-'10, think that the thorax of insects is composed of three segments. This view is supported by embryology and anatomy and is based upon facts, while all the composite segment theories are more or less lacking in such support, are not always based upon facts and consequently are untenable.

Dr. Prell, '13, who has recently published a paper on the Myrientomata, views the insect thorax as follows: In the abdomen of *Acerentomon*, he finds that each segment is divided into four rings, which are further subdivided into regions by sutures. In the thorax of *Eosentomon* these rings are represented by a number of sclerites which have become more or less displaced from the ring arrangement, owing to the specialization of the thorax for locomotion. The sternal region is composed of four subdivisions, which he terms the acro-, pro-, meso-, and metasternite. The tergal region is also composed of four subdivisions, the acro-, pro-, meso-, and metatergite and in addition a region called the nototergite becomes secondarily marked off from the metatergite. In the pleural region of each segment, he finds two longitudinal rows of sclerites. Those bordering on and extending along the lateral margin of each thoracic sternum, he terms the sternopleura or pleura in the restricted sense. Those which border on and extend along the lateral margin of each tergal region, he terms the sympleura or tergal pleura. Both sympleura and pleura are composed of four sclerites, lying one

behind the other. The dorsally situated sympleura are termed, acro-, pro-, meso-, and meta-sympleurites, while the sclerites composing the more ventrically situated row are termed the acro-, pro-, meso-, and meta-pleurites. The pleura and sympleura, he thinks, are detached portions of the region, which he terms the zygoterga. The zygoterga is the region comparable to the dorsal or tergal half of the abdominal segment. Thus he considers that each thoracic segment is composed of four subsegments designated by the terms acro-, pro-, meso-, and meta-subsegments, that the dorsum is composed of four tergites and the sternum of four sternites, designated by the above mentioned prefixes. He regards the lateral region as consisting of two longitudinal rows of sclerites (i. e., the upper row or sympleura and the lower row or pleura) and considers that they are detached portions of the zygoterga.

DISCUSSION OF THE THORACIC SCLERITES.

TERGUM. The term dorsum has been used to designate various parts of the dorsal surface of the thorax in different insects, but when correctly applied it refers to the entire dorsal surface and this usage will be followed here. The terms tergum and notum will be used interchangeably to designate the entire dorsal surface of any one thoracic segment. These terms are generally used in this sense and if given any other meaning, would lead to confusion.

In the nymphs of the lower insects as well as in many larvæ and pupæ, the tergum is a single undivided plate, the scuto-scutellum (Crampton, '09). This is probably the primitive condition of the tergum, which has possibly persisted in a more or less modified condition in the pronotum of adult insects. The fact that no postscutellum has ever been described as occurring in the pronotum of insects, supports this view. The post-scutellum in adult insects, develops in the intersegmental membrane of the mesonotum and metanotum, its development being apparently parallel with the development of the wings, which is possibly due to anatomical causes such as the stimulus of muscle stress, etc. Snodgrass, '10, calls the postscutellum the "postnotum" or "pseudonotum." There is no reason for rejecting Audouin's term postscutellum, which is suitable, widely used and generally accepted. Hence it will be retained in this paper.

Verhoeff, '02–'04, Voss, '04, and Snodgrass, '09, have proven conclusively that the tergum is composed of but two plates, the scutoscutellum (Crampton, '09) and the postscutellum (Audouin, '24), the latter being absent in the pronotum, (Fig. 13, scsl, psl). The anterior plate or scutoscutellum is generally marked off by transverse sutures into three regions, the prescutum, scutum and scutellum, but sometimes the sutures which mark the boundaries of these regions are absent(Fig. 13, prsc, sc, sl). In many insects the posterior plate or postscutellum is divided longitudinally into a median and two lateral regions, which may be subdivided (Fig. 1, psl). Crampton, '09, termed these regions the mediophragmite or median region and pleurophragmites or lateral regions. I shall use the terms mediotergite and pleurotergite for these regions, because they are subdivisions of the tergum (Fig. 1, mt, plt). When they are further subdivided by a transverse suture, Crampton, '09, refers to the subdivisions as the superior and inferior region of their respective medio- or pleurophragmite (medio- or pleurotergite). I shall refer to the subdivisions of the medio- and pleurotergite in the same manner (Fig. 1, spplt, iplt). In *Tipula* the pleurotergite is divided transversely into the superior pleurotergite and inferior pleurotergite (Fig. 1, spplt, iplt). In other Diptera such as *Leptis*, *Tabanus*, etc., the pleurotergite is subdivided by a longitudinal suture into the outer and inner pleurotergite (Figs. 2 and 11, oplt, inplt). Crampton, '09, previously used these adjectives to designate the outer and inner "pleurophragmite."

The scutellum projects laterally on both sides, until it meets the posterior margin of the wing. (Fig. 1, sl). The prescutum and postscutellum are often continued laterally on either side until they join the pleuron, although frequently these lateral prolongations become much reduced in size or split up into smaller pieces (Fig. 2, prsc, psl). Projecting internally, sometimes from the anterior margin of the tergum, sometimes from the posterior margin, or from both, is a process termed the phragma, which serves for the attachment of muscles. When the phragma is attached to the anterior margin of the tergum, it is termed the prephragma and when attached to the posterior margin, is termed the postphragma (Snodgrass, '10). The prescutum and postscutellum are frequently represented in the

tergum of insects simply by the inward projecting phragmas. In some insects the postscutellum is completely separated from the scutoscutellum by membrane. (Fig. 10, psl).

The old view that the tergum of adult insects consists of four consecutive transverse plates was proposed by Audouin, '24. He termed these plates the presecutum, scutum, scutellum and postscutellum, and this terminology has been retained though Audouin's general conception of the tergum, held until recently by most entomologists, is now obsolete. Other writers have given various names to the different tergal regions. Amans, '85, proposed the terms prodorsum, dorsum, postdorsum and subpostdorsum for the identical sclerites previously termed prescutum, scutum, scutellum and postscutellum by Audouin. Audouin's terminology has the right of priority, is widely accepted, has no undesirable features and should therefore stand.

WINGS. The wings of insects arise in two ways. In hemimetabolous insects they appear as outgrowths at the lateral margins of the meso- and metanotum. In holometabolous forms, they arise internally as the so-called wing-buds, appearing externally at or after pupation. At first the wings are filled with tracheæ, blood, tissue, etc. The tracheæ persist and are ultimately replaced by the veins or nervures of the adult insect wing, which serve as stiffening supports for the wing membrane. The blood and tissue gradually disappear and the two lateral surfaces of the sac-like outgrowth come together, forming the wing membrane.

The wings of adult insects are connected with the scutoscutellum along its lateral margin, on the lateral margin of the tergum. They articulate with the pre- and post-alar processes, together with the small alar sclerites at the base of the wing (Fig. 10, pra, poa, sa, ba). Beneath they articulate with the pleural wing process (Fig. 10, plwp).

The wings are variously modified in different insects, forming the elytra of Coleoptera, the tegmina of Orthoptera, the halteres of Diptera, the hemielytra of Hemiptera and the hairy and scaly wings of Lepidoptera and Trichoptera. In such forms as Carabidæ, Ptinidæ, and weevils the hind wings are often lacking, owing to disuse, and the elytra in some forms fuse together thereby forming a solid covering for the hind wings (if present) and the abdomen. The general belief has always been that elytra are modified wings.

In homologizing the wings in the different orders of insects, by their venation, Comstock made use of the tracheæ, which occupy the position afterwards assumed by the principal veins in the wings of generalized insects. He termed the veins costa, subcosta, radius, media, cubitus, and anals. This terminology is quite widely accepted and generally used, especially for Lepidoptera.

Several theories have been proposed to account for the origin of the wings. Gegenbauer, '70, claimed that the wings developed from tracheal gills. Palmen, '77, discredited this theory by demonstrating that tracheal gills occur on the sternum, abdomen, tergum, pleuron and in the anal region; that tracheal gills and the closed tracheal system is a secondary adaptation to the aquatic life of the larva and that aerial respiration was probably the primitive condition.

Plateau, '71, thought that the wings developed from hypertrophied spiracles. Müller, '75, from a study of the development of the wings of *Calotermes*, concluded that they arose as lateral outgrowths of the dorsum. To this theory Pancritius, '84, adds the idea, that the primitive outgrowth of the body wall may have developed into a protective body covering like an elytron, which became modified to form the wings. Packard, '98, accepted and developed Müller's theory. He apparently thought that primitive winged insects had lateral extensions of the thoracic segments, which acted as a sort of parachute and which later gave rise to true wings. Palaeontological records show that some insects had lateral extensions of the pronotum which may have served as a parachute and that many of the earliest of the Pterygota have well developed wings, which seem to have articulated with the thorax. Packard's theory is plausible.

PLEURON. The pleuron in a restricted sense consists of the sclerites lying between the dorsum and sternum and forming the lateral wall of any thoracic segment. In nearly all insects it is composed of two sclerites, the episternum or anterior sclerite and the epimeron or posterior sclerite (Fig. 8, es_1, em_1). In the higher forms, the pleuron is usually connected with the tergum by prolongations of the prescutum and postscutellum, the latter often extending downward for some distance and fusing with the pleuron, in which case it is frequently mistaken

for a part of the pleuron (Figs. 2 and 11, psl, prsc). These prolongations of the tergum are usually lacking in the lower forms. In other insects they may be much reduced in size or split up into smaller pieces.

The episternum and epimeron are separated externally by a suture, termed the pleural suture, which extends from the pleural wing process or fulcrum to the pleural coxal process (Fig. 1, pls_2). Internally these two sclerites may be readily distinguished from each other by a strongly chitinized ridge variously termed the pleural ridge, entopleuron or apodeme, which likewise extends from the pleural wing process to the pleural coxal process.

The pleuron bears three processes which usually have an inward projection for the attachment of muscles. Above is the pleural wing process which serves for the articulation of the wing (Fig. 2, plwp). It consists of a dorsal prolongation of the pleuron, of variable length, through which runs the pleural suture externally and the entopleuron internally. On the lower margin of the pleuron is the pleural coxal process, with which the coxa articulates (Fig. 4, cxp). It is similar to the pleural wing process and has the pleural suture and pleural ridge extending through it. The pleural process or pleural arm (Snodgrass, '10) is situated a short distance above the coxal process. It projects inward and downward from the entopleuron. Usually it rests against the furca (an inward projecting process of the sternum, termed the apophysis) and frequently fuses with it (Fig. 12, f).

Along the dorsal edge of the pleuron are generally found three or four small sclerites. Two of these, the basalar plates (Crampton, '14) are generally found in front of the pleural wing process, and are termed by Crampton, '14, the anterior and posterior basalar sclerites, terms which will be used in this paper (Fig. 2, pba, aba). Behind the wing fulcrum there is usually one, sometimes two of these sclerites, which are termed subalar plates (Crampton, '14, Fig. 2, sa). Lowne, '90, in his book on the Blow-Fly, terms the subalar plate, the "costa." Snodgrass, '08, terms it the "postepimeron" and Crampton, '09, the posterior "costal sclerite." Verhoeff termed the anterior basalar plate, the "alarpleura." Snodgrass, '10, termed all these plates the "paraptera." Those situated in front of the wing process, he called the preparaterum or episternal paraptera

and those behind the postparapterum or epimeral paraptera. Snodgrass claims in his "Anatomy of the Honey Bee," pp. 20, footnote (a), that Audouin, '24, termed these plates the paraptera and hence Snodgrass would retain this term. This, however, is not the case. Audouin, '24, termed the small sclerite which sometimes extends along the anterior edge of the episternum the "paraptere" and confuses it with the tegulae and other sclerites at the base of the wing. Later Audouin, '32, clearly defined the "paraptere" as the tegulae (1832 Audouin, Exposition de L'anatomie du Thorax. par W. S. MacLeay, Accompagnee de notes par M. Audouin. Ann. Sci. Nat. XXV, Ser. 1, pp. 41, footnote.) He says: "In fact I consider as the paraptere the small piece so visible in the Hymenoptera and in the Lepidoptera, which covers the base of the fore wings and which has been designated by the name ecaille, epaulette or squamala." Jordan, '02, terms the subalar plate the "parasternum" and also applies this term to the anepisternum (upper portion of the episternum) in his figures. His homologies of the sclerites are evidently incorrect. Berlese, '06, termed the basalar sclerites the "acrosterno o prefulcro (anteriore e posteriore)." The subalar sclerite he terms the "paraptero," (Gli Insetti, pp. 244). "Prefulcro" is a good term for the basalar sclerites, as it designates their position in front of the wing fulcrum, but the term "paraptero" does not seem desirable. Crampton's, '14, term, subalar sclerites, is far more suitable since it exactly describes the position of these sclerites.

The pleuron may be more or less modified in different insects. In the mesothorax of some Diptera, the parts have shifted forward, thereby causing the pleural suture to become twisted and curved (Fig. 11, pls_2). In Odonata the pleuron assumes an oblique position and as a result, the episternum becomes dorsal and the epimeron ventral. In other insects the pleural sclerites are variously modified in shape and size.

Crampton, '08, was the first to suggest that the pleuron probably consisted originally of but one plate and that the episternum and epimeron may have been formed by the infolding of the integument, due to muscle stress. This view was later developed by Snodgrass, '09. In such insects as *Eosentomon*, *Leuctra* (prothorax), acridid nymphs and *Anisolabis*, the pleuron is apparently represented by a single plate, in which the pleural suture is present. If the pleuron was originally a single plate,

which seems very probable, then the pleural suture probably arose by an infolding of the integument of this plate. In the pleuron of *Periplaneta* for example, the line which represents the pleural suture is clearly formed by the two external lips of the infolded integument coming together and resting against each other, but the edges or lips do not fuse. On pressing the edges or lips of the fold apart, a large hollow pocket will be seen, at the bottom of which is the apodeme and the pleural arm. The pleural arm is sometimes hollow and usually chitinized. These conditions would be produced by the infolding of the integument of the pleuron, possibly due to muscular stress, possibly from other causes. This is the simplest and most probable explanation.

Some investigators regard the pleuron as being formed by two sclerites coming together, fusing and the edges rolling inward to form the pleural suture and apodeme. This view seems very improbable. It is complicated and does not account for the single plate representing the pleuron in *Eosentomon*, *Leuctra*, etc. Furthermore, two sclerites whose edges meet and fuse are not apt to be plastic enough to permit their being drawn out into a prolongation forming the pleural arm and pocket, but would more probably be firm and resistant.

Audouin, '24, considered the pleuron as composed of three sclerites, the anterior or episternum, the posterior or epimeron and the peritreme or spiracle bearing sclerite. This terminology is widely accepted (with the exception of peritreme) in general use and there is no valid reason for changing it as some writers have done, since this only leads to confusion. Kirby refers to the epimeron as the pleura. Burmeister thought the pleuron was part of the sternum and others regard it as the basal sclerites of the leg.

Heymons, '99, in his "Beitrage zur Morphologie und Entwichlungsgeschichte der Rhynchoten," pp. 443, in discussing the sclerites of *Nepa*, was the first to use the term subcoxa and applied it to what he thought was the mesothoracic pleuron, consisting of episternum and epimeron. A study of *Nepa* shows that Heymons' subcoxa actually consists of the mesothoracic episternum, the precoxal bridge or precoxale (Crampton, '14), and possibly the trochantin. The sclerite in *Nepa* which Heymons thinks is the metathoracic pleuron, he terms the "pleurite," pp. 376. This sclerite is not the metathoracic

pleuron, but is the epimeron of the mesothorax. It extends posteriorly as a sort of flap covering the metathoracic epimeron, which would easily escape notice unless closely observed. Heymons was confused in the use of his own term subcoxa, which has led to its misinterpretation by other workers. Enderlein and also Berlese thought the "subcoxa" corresponded to the trochantin. Börner considered it equivalent to his "merosternum" or pleuron. Verhœff regarded it as representing the coxopleure (episternum) and trochantin.

EPIMERON. The epimeron varies greatly in size and shape in different insects. Most writers consider it as a single sclerite, which is usually the case (Fig. 8, em_1).

In the prothorax of *Periplaneta* there is a small sclerite, which has become split off from the posterior edge of the epimeron, and may be termed the postepimeron (Fig. 3, pem_1). Snodgrass, '08, applied this term to the subalar plate. It has since been discarded and so far as I know, has never been applied to any other sclerite. Therefore, as it describes the exact position of the sclerite, which has become detached from the posterior edge of the epimeron, I have adopted it to designate the sclerite in question. In the prothorax of *Capnia* (Fig. 4, pem_1), there is a large sclerite comparable to the postepimeron, which is likewise split off from the posterior edge of the epimeron and extends behind the coxa until it meets the furcasternite, thereby forming the postcoxal bridge or postcoxale (Crampton, '14). In the mesothorax of *Corydalis* (Fig. 10, pem_2) the epimeron is a single sclerite, a projection of which extends behind the coxa. In many Coleoptera and Tenthredinidæ (prothorax of *Dolerus* (Fig. 12, em_1) the epimeron is greatly reduced in size.

The epimeron is often divided into two sclerites by a transverse suture. This condition can be seen in the mesothorax of such insects as *Mantispa*, *Chrysopa*, *Leptis*, and in some Tipulidæ and Tabanidæ (Figs. 1 and 2, em_2). In Diptera the lower portion of the epimeron of the mesothorax is usually fused with the meron, being separated by a suture, although the suture is often wanting (Figs. 1 and 11, mp). Packard, '80, seems to have been the first to apply terms to the subdivisions of the epimeron. In describing the thorax of Mantispa, he termed the upper region, the sur-epimeron and the lower the

infra-epimeron. Crampton, '08, used the terms hyper- and hypo-epimeron for these regions, but on account of the similarity of the terms he later (Crampton, '09), discarded them, substituting in their place anepimeron and katepimeron.

Osten-Sacken's terminology has been widely used for the Dipteron thorax and is very good. Crampton, '14, retains it in a slightly modified form, viz.: changing the ending from pleura to pleurite. Thus in the Diptera, Crampton, '14, terms the upper region of the epimeron the pteropleurite (situated beneath the wing base (Fig. 1, ptp) and the lower region meropleurite (usually fused with the meron, especially in Diptera (Figs. 1 and 11, mp). These terms will be adopted in this paper.

Some Diptera such as *Tipula*, *Chrysopa*, etc., have the lower portion of the epimeron separated from the meron by a suture. In such cases the term katepimeron (Crampton, '09) will be applied to the lower portion of the epimeron (Figs. 1, 2 and 13, kem). The term meropleurite will be applied to the katepimeron plus the meron whether these sclerites are completely fused into one as in the mesothorax of *Tabanus* (Fig. 11, mp), or separated by a suture as in *Tipula* and *Chrysopa* (Figs. 1 and 13, mp). In either case the meropleurite represents identical regions (Figs. 11 and 13, mp).

The subalar plate or its representative is always present behind the pleural wing process (Figs. 1, 2 and 11, sa). It may be partly fused with the epimeron or entirely separated from it by membrane. Both of these conditions can be found in the Diptera (*Leptis*, *Tabanus*, etc., Figs. 1 and 2, sa). Sometimes the subalar plate is divided into two sclerites as in some of the Plecoptera, and in that case will be termed anterior and posterior subalar sclerites (Crampton, '14). In some Leptidæ and Tabanidæ, there is a cleft immediately below the subalar plate (Figs. 2 and 11, sa), which is prolonged downward into the epimeron (pteropleurite, ptp) for a short distance in the form of a suture, but the internal ridge of this suture is not continuous with the pleural suture. Snodgrass, '10, mistook this suture for the pleural suture, which it closely resembles when viewed externally. By carefully examining a specimen which has been boiled in caustic potash, the mistake will be readily discovered and the real pleural suture can be easily traced by means of the apodeme, from the coxal process into the pleural wing process (Figs. 2 and 11, pls_2).

In studying the thorax in a series of insects such as *Mantispa, Chrysopa, Tipula, Leptis* and *Tabanus*, it will be observed that there is a gradual shifting forward of the sclerites, being most pronounced in the mesothorax (Figs. 13, 1, 2 and 11). This causes the pleural suture of the mesothorax to become more or less crooked as shown in Figs. 1, 2 and 11, pls_2.

Starting at the upper end of the mesothoracic wing fulcrum of Tabanus (Fig. 11, plwp) the pleural suture (pls_2) runs downward and slightly forward in a more or less curved line until it meets the sternopleurite (lower region of the episternum). (Fig. 11, stp). Here it turns almost at right angles and runs posteriorly to the meropleurite (lower portion of epimeron), (Fig. 11, mp) and thence downward and slightly backward to the coxa. This condition is very confusing and hard to see, unless the specimen is first boiled in caustic potash, in which case the pleural suture is readily observable.

In Diptera the meron is often fused with the lower region of the epimeron, forming the meropleurite (Fig. 11, mp), but as the former sclerite is usually closely connected with the coxa it will be treated under the heading Coxa.

Audouin, '24, applied the term epimeron to the sclerite immediately posterior to the episternum. This term has been generally accepted and used by nearly all subsequent entomologists. The epimeron was termed by Burmeister, '32, the "pleura;" by Verhoeff, '03, the "anopleure;" by Amans, '85, the "postpleuron," and by Heymons, '99, the "pleurite." Hammond, Brauer and Lowne who have worked on the Dipteron thorax, where the epimeron is often subdivided into two sclerites, have applied the term epimeron to various thoracic sclerites and the terminology has been greatly confused. Osten-Sacken's terminology for the thorax of Diptera is very good and should be retained. Crampton, '14, in a review of the Dipteron thorax has retained this terminology slightly modified as previously stated. This terminology should also be applied to all insects in which the epimeron and episternum are subdivided as in *Mantispa, Chrysopa, etc.*, since it has been established by wide-spread acceptance among those working on Diptera and should be made a uniform terminology for all insects with a thorax of this nature, as far as possible.

The term parapleuron has given rise to much confusion among morphologists. It was first applied to the entire pleural

region by Knoch. Kirby termed the epimeron and episternum, the parapleuron, an interpretation accepted by Smith, '06. Burmeister and also Voss applied the term parapleuron to the episternum. Kolbe used it for a sclerite occurring in beetles, situated behind the wing and between the tergum and pleuron. Ritter's parapleuron is equivalent to the anepisternum or upper region of the episternum. Others have used the term parapleuron to designate various sclerites of the thorax. At present there is no uniformity of opinion concerning the application of the term even among Coleopterologists, by whom it is chiefly used.

EPISTERNUM. The episternum is also subject to great variation in insects. It may consist of a single sclerite as in the earwig (Fig. 8, es_1), or it may be subdivided into an upper and lower region as in *Mantispa, Chrysopa, Corydalis, Tipula,* etc. (Fig. 2, es_2). The suture which divides the episternum into two regions may extend clear across, making a complete division, as in the mesothorax of *Tabanus* (Fig. 11, g) or only part way, as in the mesothorax of *Tipula* (Fig. 1, g). In *Chrysopa* and *Mantispa* (Fig. 13), the division is represented by a narrow strip of chitin of varying width, extending inward midway between the two subdivisions. This strip is probably a part of the episternum which has become fused with the precoxal bridge (Crampton, '14). It may, however, belong entirely to the precoxal bridge, a projection of which extends between the two subregions, but this latter alternative is very improbable. The formation of this region in other insects seems to indicate that it is a part of the episternum. Crampton, '09, applied the term "median region," to this narrow strip of chitin. This seems to be the only term which has been applied to it. It hardly seems necessary to give this region a name and consequently none will be used in this paper.

When the episternum is subdivided, a condition found in a great many insects, the lower division may be fused with the sternum (Figs. 1, 2 and 11, stp). The episternum is separated from the epimeron by the pleural suture. In all insects, both the episternum and epimeron extend from the coxal process to the pleural wing process. This condition can be plainly seen in most insects, but in some such as Tabanus, etc. (Fig. 11, stp), the lower portion of the episternum of the mesothorax has

become fused with the sternum. Many workers have considered this fusion product of sternum and lower portion of the episternum as the entire sternum and accordingly termed it the sternum. This misinterpretation has led to great confusion in the terminology. In the mesothorax, Lowne termed this composite region the "mesoplastron." He also applied the term, "metaplastron" to the meropleurite (lower portion of epimeron fused with the meron) of the mesothorax (Fig. 11, mp). Chabrier had originally used the term "plastron" to designate the pleuron of the prothorax, so that Lowne is incorrect in stating that the "mesoplastron" is the "plastron" of Chabrier. Packard, '80, used the terms sub- and infra-episternum to designate the fusion product of the sternum and lower region of the episternum. Snodgrass, '10, and several other workers termed it the "sternum." Osten-Sacken, '89, used the term "sternopleura." Crampton, '09, designated it by the component parts entering into its composition, but later Crampton, '14, adopted Osten-Sacken's terminology, slightly modified, calling it the sternopleurite. The latter term will be used in this paper.

The lower portion of the episternum in *Chrysopa* and like insects has a new region marked off, which is composed of a different combination of sclerites than the region representing the sternopleurite in *Tabanus*, and hence has been termed pleurotrochantin, (Crampton, '14) (Fig. 13, pltn). This term will be retained in this paper. The pleurotrochantin is composed of the lower part of the episternum, most of the trochantin and the antecoxale. The term sternopleurite, however, will still be applied in *Chrysopa* and like insects, to the pleurotrochantin plus the precoxale and sternum (Fig. 13, stp), since this region would then be identical with the sternopleurite of Diptera (Fig. 11, stp). In this way a uniformity of terminology is retained.

The upper region of the episternum is a more or less square sclerite, which has become pushed forward in the mesothorax of such insects as Tabanus (Fig. 11, esp), due to the shifting forward of the parts as previously mentioned. The upper margin of this sclerite and also the pteropleurite (upper portion of the epimeron) often contain clefts of varying depth and width (Figs. 2 and 11). The shifting forward of sclerites naturally led to their misinterpretation by different workers and finally

resulted in a confused terminology. Packard, '80, termed the upper region of the episternum, the "sur- and supra-episternum.' Hammond, '81, called it the "parapteron." Brauer, '82, and several other workers called it the episternum, while Snodgrass, '09, included a portion of the pteropleurite (upper region of the epimeron) and the upper region of the episternum together, as the episternum. Lowne, '90, termed it the lateral plate of the "mesosternum," Petri, '99, the "antepleura," borrowing Amans '85, term for the entire episternum, (antepleuron). Osten-Sacken, '84, termed it the "mesopleura," which is inappropriate, because it is not the entire mesopleuron. Crampton, '08, called it the "hyper-episternum" and later, Crampton, '09, the "anepisternum." I shall adopt for it the term anepisternum. In *Chrysopa*, *Mantispa*, etc., (Fig. 13, esp, ptp) the terms anepisternum and also pteropleurite have been used for the upper portions of the episternum and epimeron, since these regions are homologous with those found in Diptera (Fig. 11, esp, ptp).

In the meso- and metathorax of *Periplaneta* the episternum consists of one sclerite, which is fused with the precoxal bridge or precoxale (Crampton, '14) (Fig. 3, es, es_3). The trochantin is partially attached to the episternum in the prothorax (Fig. 3, tn_1). The episternum, together with the epimeron form a deep hollow pocket by the infolding of the integument, which bears internally the pleural process. The episternum in the earwig consists of a single sclerite (Fig. 8, es_1).

In *Capnia* the prothoracic episternum consists of one piece (Fig. 4, es_1). The meso- and metathoracic episternum is divided by a suture into an upper and lower portion (Fig. 4, esp, pltn) giving a condition comparable to that found in Chrysopa (Fig. 13, esp, pltn). Here also we have the beginning of a condition similar to that found in *Tabanus* (Fig. 11, esp, stp). The fusion of the sternum with the lower portion of the episternum, precoxale, etc., suggests the probable formation of the sternopleurite (Figs. 1, 2 and 11, stp).

In *Corydalis* the condition of the episternum in the mesothorax is similar to that found in *Capnia* and *Tabanus*. (Fig. 10, esp, stp). The suture dividing the episternum becomes more pronounced and takes the form of a deep cleft. The precoxale, sternum and episternum become more closely fused.

Packard, '80, in his figures of *Corydalis* shows the episternum extending from the coxa to the wing process. He also includes the trochantin and precoxal bridge as part of the episternum. Crampton, '09, considered the episternum as extending from the coxal process to the pleural wing process. Snodgrass, '09, regarded the anepisternum (upper portion of episternum) in *Corydalis*, as the entire episternum (Fig. 10, esp). The episternum, however, extends from the coxal process to the pleural wing process, as is very clearly illustrated in *Periplaneta*. Most writers fail to take this fact into consideration and consequently the resulting misinterpretation and confusion.

In *Dictyophora* and *Dissosteira* the sternum, episternum and precoxale are closely united. This condition is more or less pronounced in the various insect orders. In the pro-, meso- and metathorax of *Forficula* (Fig. 8, pc_1, pc_2, pc_3) and in the mesothorax of *Gryllus*, (Fig. 7, pc_2) the precoxale becomes split up and is not fused with the sternum. In the prothorax of *Gryllus*, however, the episternum, precoxale and sternum are closely united (Fig. 7, pc_1, es_1, vs_1).

Audouin, '24, termed the anterior plate of the pleuron the episternum. This term is still in use and accepted by everyone. When the episternum is subdivided it is necessary to use other terms to designate the subdivisions, as previously discussed in the case of *Tabanus*, *Mantispa*, *Chrysopa*, etc. Burmeister, '32, termed the episternum the "parapleura." Packard, '80, called the upper portion the sur- and supra-episternum and the lower portion the sub- and infra-episternum, using the former and also the latter terms interchangeably. Packard studied a large number of insects and used the terms, "pleurites" and "sternites," in his terminology. Although his homologies of the sclerites are incorrect in many cases, his ternimology has many good points. His work on the whole is very good and has not been accorded sufficient attention. Amans, '85, termed the episternum the "antepleuron." Jordan, '02, applied the terms "para-sternum" and "episternum" to the anepisternum (upper portion of episternum). The term "parasternum" he also applies to the basalar plate. The sternopleurite (lower portion of episternum fused with a part of the sternum), he terms "hyposternum." He confuses his own terms by misinterpreting the sclerites in different papilionids. In *Forficula*,

Verhoeff, '03, termed the episternum the "coxopleure," while in the roach his "coxopleure" consists of the precoxale together with the episternum.

Audouin's, '24, term episternum is satisfactory and generally accepted, while the other terms applied to the episternum are useless synonyms. This confusion was brought about by the misinterpretation of sclerites and by the tendency of writers to set forth their own ideas of the terminology. In doing this, they have invented new terms to suit their respective views and have not given sufficient attention to the work and terminology of previous investigators.

PRECOXALE. The precoxale is situated in front of the coxa and is either united or completely fused with the episternum. The end of this sclerite nearest the sternum may be free as in *Periplaneta* (Fig. 3, pc_1), or it may be united or fused with the sternum as in the mesothorax of *Capnia* (Fig. 4, pc_2), thereby forming a bridge connecting the episternum with the sternum. Hence the term precoxal bridge or precoxale of Crampton, '14. The portion nearest the sternum is sometimes split transversely into one or two small sclerites, as in the mesothorax of *Forficula* (Fig. 8, pc_2). In other cases the precoxale is entirely fused with the episternum and sternum as in the Coleoptera, Formicina, Diptera, etc. (Fig. 10, pc). A portion of it may fuse with the episternum and a portion with the sternum as illustrated in the metathorax of *Forficula* (Fig. 8, pc_3), or it may disappear as in the prothorax of *Macroxyela* (Fig. 14). The division between sternum and episternum in the metathorax of *Forficula* (Fig. 8, es_3, vs_3) is probably secondary, although this condition is open to other interpretations.

The precoxale, while constant in position is extremely variable in size and form. In *Periplaneta*, which is admittedly a very primitive insect, the precoxale is similar in all three thoracic segments, its dorsal portion being always fused with the episternum, except in the prothorax, while the ventral portion borders on the sternum, but is not strongly connected with it (Fig. 3, pc_1, pc_2, pc_3). In the meso and metathorax, there is a deep cleft in front of the pleural wing process, at the mouth of which is a small sclerite, comparable to one of the basalar sclerites, previously discussed (Fig. 3, pba_2, pba_3).

The other basalar plate is probably represented by a small sclerite, which is marked off on the upper corner of the precoxale by a heavy suture (Fig. 3, aba_2, aba_3).

In *Periplaneta* there is a suture which divides the meso- and metathoracic episternum and precoxale (Fig. 3, 0). Part of it can be plainly seen and the other part (represented by the dotted line) is rather faint and hard to see. If the specimen is first boiled in caustic potash, the suture can be more easily distinguished. This suture suggests very strongly the beginning of the formation of a sclerite, comparable to the anepisternum (upper portion of the episternum) of the Diptera. In some roaches it is represented by one heavy suture, plainly seen throughout its entire length.

Along the anterior margin of the metathoracic precoxale there is marked off a small sclerite, which I shall term the pre-episternum (Fig. 3, pes_3). It seems to be homologous with Audouin's '24, "hypoteron." Hopkins first used the term pre-episternum to designate the sclerite which Audouin termed the "hypoteron," in *Dytiscus* and it should be applied to that sclerite only. Jordan, '02, terms the pre-episternum the "peristernum." Snodgrass, '09, has used the term pre-episternum, but is so inconsistent in its application that it is hard to tell what his pre-episterum represents. In his various figures, he has designated the episternum, precoxale, one of the basalar sclerites and the pre-episternum proper, by the term pre-episternum. In his "Thorax of the Hymenoptera," he calls the pre-episternum the "prepectus."

Immediately posterior to the precoxale in *Periplaneta*, a narrow sclerite is marked off, the antecoxale of Crampton, '14, whose term I shall adopt for this sclerite. This sclerite is folded under the precoxale in the prothorax (Fig. 3, ac_1) and is homologous with the lateral portion of the antecoxal piece of Coleoptera. It is connected with the precoxale in *Periplaneta* by very thin or non-pigmented chitin, not by membrane. This suggests that it is probably derived from the precoxale by a secondary longitudinal marking off. In other insects it has either disappeared or become fused with other sclerites which surround it, such as the trochantin, precoxale, etc. The antecoxale was termed by Walton, '00, the "antecoxale piece;" by Comstock, '02, the "second antecoxale piece," and by Crampton, '09, the "antecoxale laterale." Verhoeff, '03,

terms it the "katopleura" in the roach, but in the Forficulidæ he applies the term "katopleura" to an entirely different sclerite.

In *Forficula* the condition is quite different from that found in *Periplaneta*. In the prothorax the precoxale may have fused with the trochantin and episternum following which there was a secondary marking off, of a triangular sclerite, consisting partly of trochantin and precoxale (Fig. 8, tn_1), and of two narrow sclerites extending along the anterior margin of the episternum (Fig. 8, pc_1), which represent a part of the precoxale, the rest of it having fused with the episternum. Another view is that the triangular sclerite (Fig. 8, tn_1) represents the entire trochantin and that the two narrow sclerites along the anterior edge of the episternum represent the entire precoxale (Fig. 8, pc_1), which has become reduced in size. The precoxale in *Diapheromera* is very narrow and reduced in size, thus showing that such a condition is not at all abnormal or improbable.

In the mesothorax the precoxale has become split transversely into two sclerites (Fig. 8, pc_2). For the sclerite nearest the sternum, I suggest the term sternocoxale (Fig. 8, stc) and for the sclerite nearest the pleuron, the term pleurocoxale (Fig. 8, plc). In the metathorax a portion of the precoxale may have fused with the episternum, sternum and trochantin (Fig. 8, pc_3). How much has fused with each, it is impossible to say. Another view is that the pleurocoxale has fused with the episternum; the sternocoxale with the sternum and the triangular sclerite (Fig. 8, tn_3) represents the entire trochantin. In the thorax of Forficula there is no complete connection between the episternum and sternum.

There is small sclerite between the pleural region and sternum in the mesothorax of *Gryllus*, which is homologous with the sternocoxale (Fig. 7, stc). Voss termed it the "coxosternite."

In Locusta, *Capnia*, *Corydalis*, and many Lepidoptera, Diptera, Coleoptera, etc., the precoxale is usually fused with the episternum and sternum, forming a continuous bridge between them (Fig. 4, pc_2). Secondarily formed sutures often appear in this bridge or precoxale, as in *Capnia*, *Corydalis*, etc.

The precoxale shows an interesting transition in the prothorax of sawflies. In *Abia* and also *Cimbex*, the episternum and sternum are connected by the precoxale (Fig. 15, pc). The

latter is in the process of disappearing in *Dolerus* and is represented by a small sclerite on either side of the sternum (Fig. 12, pc). These small sclerites are not connected with either the sternum or episternum, but lie half way between them. In *Macroxyela* all trace of the precoxale is lost (Fig. 14). There is no indication of the connecting bridge between episternum and sternum, but the sternum is larger than in *Dolerus* or *Abia* and probably represents the fusion product of a part of the precoxale and sternum (Fig. 14, vs).

The terminology of the above discussed sclerites is somewhat confused. The precoxale was termed "laterale" by Crampton, '09 and "precoxal bridge" or "precoxale" by Crampton, '14. The pleurocoxale was termed "katopleura" by Verhoeff, '03, in the Forficulidæ, and in the Blattidæ he applies the same term to an entirely different sclerite, showing that his homologies of the thoracic sclerites are evidently incorrect. It was termed "episternal laterale" by Crampton, '09, and "lateropleurite" by Crampton, '14. The sternocoxale was termed "vorplatte," by Verhoeff, '03, "sternal laterale" by Crampton, '09, and "laterosternite" by Crampton, '14.

In introducing the terms pleurocoxale and sternocoxale, an effort has been made to improve the terminology of these sclerites. They are more or less closely associated with the precoxale and antecoxale of Crampton, '14, and all are situated near the base of the coxa. Hence the sclerites composing this region have been given a uniform ending, which with the prefix, denotes quite accurately the respective positions of these sclerites. The term trochantin is so widely known, accepted and used that it would not be advisable to change it. This, however, does not apply to the other sclerites mentioned above.

TROCHANTIN. The trochantin is a more or less triangular shaped sclerite situated at the base of the coxa (Fig. 3, tn_1). It varies in size being quite large in some insects (*Periplaneta*, Fig. 3, tn_2) and small in other forms. (*Tipula*, *Capnia*, *etc.*, Fig. 4, tn_1). In some forms, such as in the prothorax of *Periplaneta*, *Capnia*, etc., the basal portion of the trochantin is fused for a short distance with the episternum (Fig. 3, tn_1). In other insects it is partially or completely fused with the episternum and precoxale or else has disappeared. These various

conditions of the trochantin are illustrated in such insects as *Corydalis*, *Capnia*, some Orthoptera, Trichoptera, Diptera, Coleoptera, etc. When the trochantin is present and not completely fused with other sclerites, it always articulates with the coxa.

In the prothorax of *Periplaneta* the trochantin has become transversely split into two sclerites, the upper and larger of which has been termed trochantinus major (Crampton, '09) (Fig. 3, tnm), and the lower and smaller the trochantinelle (Crampton, '14) (Fig. 3, tnl). Other writers consider the trochantinelle as the entire trochantin, but this is a mistake as one can readily see by comparing the trochantin of the prothorax with that of the meso- and metathorax, in which it is not divided transversely into two sclerites. The end of the trochantin which articulates with the coxa is constant in position in all three thoracic segments and bears at its extremity a small inward projecting process (Fig. 3, atn). In the prothoracic segment the trochantin is fused with the episternum for a short distance and is separated from the rest of the episternum and antecoxale, partly by suture and partly by membrane (Fig. 3, tn_1). In the meso- and metathorax, the trochantin is entirely marked off from the episternum and antecoxale by membrane (Fig. 3, tn_2).

In *Periplaneta*, the trochantin also has a distinct, heavy, longitudinal suture, dividing it into an anterior and posterior region, termed ante-trochantin and post-trochantin (Crampton, '14) respectively (Fig. 3, atn, ptn). This suture occurs in the trochantin of the pro-, meso-, and metathorax of the roach and can be plainly seen. In the prothorax (Fig. 3, tn_1) where the trochantin is divided into two sclerites, this longitudinal suture extends through both, thus showing that these two sclerites are equivalent to the sclerites in the meso- and metathorax which everyone admits is the entire trochantin.

In the mesothorax of *Corydalis* the trochantin is partly fused with the episternum and antecoxale. A part of it which corresponds to at least a portion of the trochantinelle, projects free and is partly constricted off from the rest of the trochantin (Fig. 10, tnl). This would indicate that the trochantinelle in the prothorax of *Periplaneta* is a detached portion of the trochantin. In *Corydalis* the portion of the trochantin which

projects free is also divided longitudinally by a suture into an anterior and posterior region (Fig. 10, tnl). It articulates with the coxa and has an inward projecting process at its extremity. These features are also present in the trochantin of *Periplaneta*.

The trochantin of the pro- and metathorax in *Forficula*, assumes the shape of a triangle (Fig. 8, tn_1, tn_3). This sclerite may be the entire trochantin or it may be the fusion product of the trochantin and part of some other sclerite such as the precoxale or antecoxale. In the mesothorax there are three small sclerites between the trochantin and the coxa, one of which is probably a detached portion of the coxa and the others of the trochantin (Fig. 8, tn_2).

Sharp, '95, in discussing the thorax of insects (Camb. Nat. Hist. vol. V, pp. 222) figures the base of the front leg and part of the prothorax of *Blabera gigantea*. He finds the homologies of the thoracic sclerites difficult to determine and his figure is wrongly labeled. The region marked "epimeron" is a part of the trochantin; the "fold of the pronotun" is the epimeron and the sclerite he has termed the trochantin is only a part of the trochantin, viz., the trochantinelle.

Packard, '98, terms the meron the "trochantin." Jordan, '02, terms a small sclerite lying along the anterior margin of the coxa, the "trochantin." Comstock, '02, termed the post-trochantin the "trochantin;" the ante-trochantin, the "first antecoxal piece," and the antecoxale, the "second antecoxal piece." Berlese, '06, terms the trochantin the "subcoxa." Snodgrass, '09, Verhoeff, '02-'04, and others have termed the trochantinelle, the entire trochantin. Crampton, '09, used the term, "trochantinus minor," to designate the trochantinelle and the terms "coxal trochantin" and "antecoxal trochantin" to designate the post- and ante-trochantin.

COXA. The coxa is the basal segment of the leg and the only one, which it will be necessary to consider in this paper. It varies greatly in size and shape in different insects, but is always constant in position and serves as a landmark in homologizing the thoracic sclerites. In some forms it is undivided and in others it is composed of two or more pieces (Fig. 8, cx_3). It articulates with the coxal process and with the trochantin when the latter is present.

In *Periplaneta*, *Corydalis*, *Dictyophora*, etc., a narrow, heavily chitinized area is marked off by a suture along the anterior margin of the coxa (Fig. 10, cm). Crampton, '09, termed this region the "Coximarginal sclerite." There is also found in some insects a small sclerite with an inward projecting process, which is free, absent or attached to the anterior margin of the coxa, and is comparatively unimportant.

A glance at the coxa of the meso- and metathorax of *Periplaneta* will show that it is partly divided into an anterior and posterior region (Fig. 3, m. vcx). The posterior region will be termed the meron (Walton, '00) and the anterior, the veracoxa (Crampton '14). The suture which marks the divisions of the coxa, is apparently a continuation of the pleural suture. In *Periplaneta* the meron is partly fused with the coxa and partly divided from it by a suture (Fig. 3, m). The meron when present appears to be developed in the meso- and sometimes in the metathorax. I have never observed its presence in the prothorax and in some Diptera it is absent in the pro- and metathorax. Hence the development of the meron may possibly have some connection with the development of the wings. The coxa was probably originally one undivided sclerite and the meron has been derived from it secondarily. Where the meron does not occur, the coxa probably represents a persistent primitive condition, such as frequently occurs in insects.

In some insects the meron is completely marked off from the coxa by a suture (Fig. 4, m) and in many forms such as Diptera, it has become drawn upward or enlarged, so that it extends into the epimeral region and is often fused with the epimeron (Figs. 1, and 2, m). This has led to its misinterpretation in the Diptera by Snodgrass, '09, and others, who have considered it to be part of the sternum. The meron is separated from the sternum by membrane in such insects as *Tabanus*, *Tipula*, etc., and the sternum can be plainly seen to extend behind the meron (Fig. 11, msst).

Snodgrass, '09, considered the meron as derived from the epimeron. In the larva of *Corydalis*, he finds the epimeron marked off into an upper and lower region. In the pupal stage he finds that the lower portion of the epimeron has extended behind the coxa and partly fused with it. In the adult, he

finds this region has fused entirely with the coxa and is separated from the epimeron by membrane. He also finds similar conditions in the larval, pupal and adult stages of Trichoptera. It seems more probable however, that the meron is part of the coxa and derived from it, as the condition found in the roach plainly indicates. The roach is also a more primitive insect than the Trichoptera, etc. In some insects (*Tipula*, *Mantispa*, etc.) the epimeron is divided into an upper and lower region and the meron is also present. This would probably not be the case if the meron were equivalent to the lower portion of the epimeron (Figs. 1 and 13, m).

The position of the coxa in its various relations to the other parts of the thorax in different insects, has led to the formulation of various theories from time to time.

Thus Miall and Denny, '86, from a study of the roach, concluded that the sclerites at the base of the leg, represent two basal leg joints, which became attached to the thorax.

Heymons, '99, in his studies on *Nepa* designated the sclerites at the base of the leg (episternum, precoxale, etc.) as the "subcoxa," and adopted Miall and Denny's view, that this region represents the basal portion of the leg.

Several writers including Hansen, Jourdain, Börner and Henneguy, have compared the styli found on the meso- and metathoracic coxæ in certain insects, to parts (exopodite, epipodite, etc.) of the crustacean leg. Banks, '93, considered the styli as vestigial legs and Verhoeff, '02–'04, regarded them as homologous with the coxal organs of Myriopoda.

Walton, '00, considered the meron as a vestigial leg, but has since retracted this statement.

Most of the above mentioned theories have already been discussed under the heading, Historical Review, and it will not be necessary to consider them further here.

STERNUM. The term sternum was originally applied to the whole ventral surface of any thoracic segment and is everywhere used in this sense. This, of course, prohibits the use of the term sternum for a subdivision of itself, although several writers have used it in both senses and thus have allowed opportunity for more or less confusion.

The sternum is probably composed of five subdivisions, which vary greatly in size and shape in different insects. In

some Hymenoptera and Coleoptera they are all fused into one sclerite. Three of these subdivisions are usually present in most insects, while the other two occur in only a few. For these sclerites, I shall use a modification of Crampton's '09, terminology, designating the subdivisions of the sternum as sternites. Thus as far as possible, without leading to confusion, the subdivisions of the tergum, pleuron and sternum will be designated by the endings tergite, pleurite, and sternite respectively.

The presternite (Fig. 4, prs_1), or anterior division of the sternum is derived from the verasternite ("sternum" or "basisternum" of other writers) and is absent in most insects. In the prothorax of *Ectobia lapponica* the presternite is in the process of becoming detached from the verasternite (Fig. 9, prs). In the prothorax of *Capnia* it is completely detached from the verasternite and lies directly in front of it (Fig. 4, prs_1). It is quite a large, oblong sclerite and has frequently been mistaken for one of the neck sclerites, owing to its position. The presternite is also found in the meso- and metathorax of *Capnia* (Fig. 4, prs_2, prs_3) and in the prothorax of *Forficula* (Fig. 8, prs). The presternite is also present in *Raphidia* and has been figured in the metathorax of *Pteronarcys* by Comstock and Kochi, '02. In the latter insect it is similar in shape to the presternite of the prothorax of *Ectobia lapponica* and is attached to the verasternite in the same manner. Comstock and Kochi, '02, have termed it the "presternum." In all other insects examined, the presternite is either absent or indistinguishably fused with the verasternite.

The verasternite is a large sclerite of variable shape lying immediately posterior to the presternite, when the latter is present (Fig. 8, vs_1). It is found in all insects and is often fused at its anterior corners with the precoxale, thereby forming the connecting bridge between the episternum and sternum (Fig. 7, vs_1). In such insects as the Lepidoptera, Diptera, etc., the verasternite is divided longitudinally by a median groove formed by an infolding of the chitin (Fig. 14, vs). Internally this groove is represented by a longitudinal, chitinous ridge. In *Ectobia* the verasternite is divided diagonally by two sutures into four sclerites and the precoxale is not fused with it (Fig. 9, vs).

The furcasternite is situated directly behind the verasternite and is usually a much smaller sclerite, although quite variable in shape in different insects (Fig. 7, fs). It is usually fused with the verasternite, but may be detached as in the prothorax of *Periplaneta* (Fig. 3, fs_1). In insects where fusion of the furca- and verasternite occurs, the former is often divided longitudinally by the median groove, exactly as in the verasternite (Fig. 14, fs). This median infolding of the integument does not occur in primitive insects and is probably a secondary modification of the more specialized forms.

Internally the furcasternite bears two processes or furca. These are usually hollow, strongly chitinized apophyses and are always present (Fig. 3, f). The furcal arms usually abut against the apodemes (pleural arms) and very frequently are closely united with them, thus forming a strong internal connection between the pleuron and sternum.

Externally the furcasternite is easily distinguished, even when fused with the verasternite. Sometimes in such insects as *Capnia*, it is connected with the epimeron (Fig. 4, fs_1). This is brought about by a narrow sclerite (postepimeron), which extends from the epimeron behind the coxa and joins the furcasternite, thus forming a connecting bridge. When the precoxale and verasternite are also fused, a complete ring is formed inclosing the coxa.

The pleural suture, together with the suture which extends between the veracoxa and meron and the one which separates the furca and verasternite, present a condition which has given rise to several double segment theories, but it does not necessarily follow that these sutures mark a division between two segments, as previously discussed.

The furcasternite in the prothorax of *Periplaneta* is a single, transverse, oval sclerite (Fig. 3, fs_1). In the meso- and metathorax it is Y shaped and fused with the verasternite (Fig. 3, fs_2, fs_3). In some forms it is also fused with the spinasternite (discussed later) as in some Lepidoptera, etc., while in others, such as in the prothorax of *Leuctra*, it is divided into two sclerites. Thus there are a few modifications in different insects.

There are indications of a fourth division of the sternum in a few insects, but it is usually absent. In the prothorax of *Capnia*, it is a single, large, oval sclerite, lying behind the

furcasternite (Fig. 4, pfs_1). In *Leuctra* this sclerite is divided longitudinally into two small sclerites. In *Periplaneta* the fourth division or postfurcasternite, is probably represented by two small sclerites on either side of and behind the furcasternite. (Fig. 3, pfs_1).

The spinasternite or fifth division is generally present and usually quite small and variable in shape (Fig. 3, ss). It bears a single internal apophyses, the spina, which is usually hollow. This sclerite lies behind the postfurcasternite, when the latter is present and behind the furcasternite when it is absent. The spinasternite in some insects is free or attached to the mesothoracic verasternite. In others it is either united or fused with the furcasternite. It is so variable in position that it is very hard to tell to which segment the spinasternite belongs, but it probably belongs to the segment in front of it, as no spinasternite has ever been described as occuring in front of the prothoracic verasternite. In the prothorax of *Corydalis*, *Forficula*, etc., it is very small, being represented by the internal apophyses only (Fig. 8, ss_1).

Audouin, '24, applied the term sternum to the entire ventral surface of any thoracic segment. It has since been used to designate various subdivisions of the sternum by different authors and this has naturally led to some confusion.

Mac Leay, '30, thought that each thoracic segment was composed of four subsegments and hence assumed that the sternum was composed of four subdivisions. He accordingly proposed the terms praesternum, sternum, sternellum and poststernellum for these supposed subdivisions.

Newport, '39, adopted Mac Leay's views, but was unable to find four subdivisions in the sternum of any living insect. Mac Leay's terminology, however, has been used by several writers.

Crampton, '09, used the terms presternum, basisternum, furcisternum, postfurcal sclerite and spinasternum, each sclerite being named after some characteristic which it bears. I have adopted this terminology in a slightly modified form, using the prefixes (except "basi") with sternite, to denote the subdivisions of the sternum.

Comstock and Kochi, '02, in their figures of the metathorax of *Pteronarcys* and *Stenopelmatus*, have labeled the first abdominal segment the "sternellum." In their figures of the neck

plates of *Gryllus*, *Periplaneta*, etc., they have designated the posterior ventral cervical sclerite the "sternellum." Consequently it is impossible to decide to what sclerite they intend the term "sternellum" to be applied.

Snodgrass, '09, used Mac Leay's terminology for the sternum, but later he used the term "eusternum" instead of "sternum," to designate the verasternite, or second division of the sternum. Snodgrass, '09, however, found and named only three subdivisions of the sternum, the presternum, sternum and sternellum. The assumed poststernellum of Mac Leay is neither figured nor mentioned. His claim that the presternum consists of two plates and that it is equivalent to the "vorplatten" of German entomologists is incorrect. The presternum consists of only one plate in all insects in which it has been found and the "vorplatten" are parts of the precoxale. Furthermore in his figures, the true presternum is not shown, but in each case some other part of the sternum is designated as the presternum.

Berlese, '06, considered the whole thoracic sternum as composed of the pro-, acro-, meso- and metasternites. He found that each of the latter was divided into two sclerites, which he termed the "sterni" and "sternelli." These subdivisions (sterni and sternelli) are incorrectly homologized in the different insects figured in his work. He has interpreted the "sternelli" as the spinasternite, as the first abdominal segment, as the spinasternite plus the furcasternite, as the verasternite, etc. Hence his interpretations of the sclerites are so inconsistent in his figures, that it is impossible to tell what sclerite he intends to designate by his "sterni" and "sternelli."

INTERSEGMENTALIA. Between the thoracic segments in such insects as the Orthoptera, Plecoptera, Trichoptera, Neuroptera, etc., there are usually a few small sclerites (Fig. 4, i). These vary in number, size and shape in different insects and include the plates surrounding the spiracle when the latter is present. They have been appropriately termed the intersegmentalia (Crampton, '09) because they are situated in the intersegmental membrane.

The intersegmentalia may be either detached portions of the segment in front of them, of the segment behind them, or of both. Which supposition is correct it is impossible to say,

without first working out the musculature of these sclerites. Whether the spiracle belongs to the segment in front, or behind it, is still a disputed question, although it seems very probable that each spiracle belongs to the segment behind it.

In the dorsal neck region of *Periplaneta* there is a small sclerite (Fig. 5, dcs), which seems to be homologous with a similar sclerite found in the dorsal intersegmental region between the pro- and mesothorax of *Corydalis* (Fig. 6, i). This would indicate that the neck sclerites and the intersegmentalia are homologous.

Voss, '04, Heymons, '95, and Palmén, '77, have proposed various theories concerning the spiracles. From a study of the musculature, Voss, '04, claims that they belong to the segment in front of them. From a study of their embryology, Heymons, '95, concluded that they lie in the anterior portion of their respective segments, but may secondarily move forward and become attached to the segment in front of them. Palmén, '77, thought that the first thoracic spiracle might be either pro- or mesothoracic, varying in different insects. It is generally agreed among most workers that the third thoracic spiracle belongs to the first abdominal segment. Of the three theories mentioned, Heymons' seems to have the most support, but more investigation on this point is necessary before it can be definitely settled.

CERVICAL SCLERITES. Embedded in the soft neck region of most insects are found a varying number of sclerites, differing in size and shape in different insects (Fig. 3, lcs, vcs). These sclerites are designated by the term "Cervical Sclerites" (Huxley, '85) or "microthoracic sclerites" (Verhoeff, '02-'04), etc. In this paper the term cervical sclerites will be adopted for these neck plates.

There can be no question that the cervical sclerites of one insect are in general homologous with the cervicals of other insects. But difficulty arises as to the origin of these neck plates and their homologies. They may be either detached portions of the head or of the prothorax or of both, while some have even considered them as the remains of one or more primitive segments. Each of these four theories has its own adherents and which one is correct, it is impossible to say at present. The cervical sclerites furnish support for the head

and it appears very probable that they are detached portions of both the head and prothorax. In some forms such as *Forficula*, *Dolerus*, etc., the lateral cervical bears an inward projecting process (Fig. 14, ap).

In *Periplaneta* there are two large lateral cervicals on either side of the neck and two ventral cervicals (Fig. 3, lcs, vcs). The lateral sclerites articulate with the head and prothoracic precoxale. This is true of all insects where the lateral cervicals occur except when they are fused with the precoxale and episternum (Fig. 7, lcs). In the latter case they articulate with the head alone (Fig. 12, lcs). The lateral cervical sclerites in *Periplaneta* articulate with small sclerites attached to the head as shown in (Fig. 3, a). The lateral cervicals very nearly meet in front of the prothoracic verasternite in *Periplaneta* (Fig. 3, lcs). The lateral cervical sclerites in *Gryllus* consist of one large plate on either side of the neck, which probably represents the fusion product of the two lateral sclerites found in the roach and other insects (Fig. 7, lcs). The two ventral sclerites in the roach, have evidently become split into five small sclerites in *Gryllus* (Fig. 7, vcs).

There is only one ventral cervical sclerite in *Forficula* and *Capnia*, the other having disappeared, while the lateral cervicals in the former are more numerous than in the latter (Figs. 8 and 4). Both of these insects have a large, more or less oval sclerite situated directly in front of the prothoracic verasternite (Figs. 8 and 4, prs), which has been mistaken by several writers for a cervical sclerite. This sclerite is in reality the presternite, which has become detached from the verasternite. In the prothorax of the roach *Ectobia lapponica*, the presternite is seen in the process of becoming detached (Fig. 9, prs). It has been found, however, in only a few insects.

The cervical sclerites are quite numerous in the lower insects such as *Periplaneta*, *Gryllus*, etc. (Figs. 3 and 7). In the higher insects (Neuroptera, Lepidoptera, Diptera, etc.), there is a tendency for the cervical sclerites to fuse together and increase in size, which becomes more marked in the more specialized forms (Fig. 2, lcs). The cervical sclerites in many Coleoptera have disappeared or have become indistinguishably fused with the prothoracic plates. In some Hymenoptera (Tenthredinidæ) the lateral cervicals have become fused with the prothoracic episternum (Fig. 12, lcs).

Snodgrass, '10, from a study of the Hymenopteron thorax, concluded that the large sclerite which lies in front of the coxa and "prosternum" (prothoracic verasternite) of sawflies, was the "proepisternum" (Fig. 15, lcs). He bases his claim upon the position of the pleural suture. A small sclerite which adjoins the "proepisternum" dorsally in *Dolerus*, he admits is a cervical sclerite (Fig. 12, lcs). The conclusions reached by Snodgrass, '10, appear incorrect for several reasons. It is more probable that the conditions found in the prothorax of sawflies, is the result of a fusion of the cervical sclerites with the episternum, in which the cervicals have become enlarged and the episternum and epimeron have become greatly reduced in size. The fusion and enlargement of the cervicals is very noticeable in the higher insects (Tipulidæ) while a reduction of the episternum and epimeron is found in practically all insects. Furthermore, the episternum never meets in front of the prothoracic verasternite and never articulates with the head, as do the cervical sclerites and also the "proepisternum" of Snodgrass, '10, in the sawflies.

A more conclusive proof that sawflies have a large lateral cervical may be obtained from a study of *Abia*, *Dolerus*, and *Macroxyela* in the order named. In the prothorax of *Abia* the precoxale or bridge which connects the episternum with the verasternite in a large number of insects can be plainly seen (Fig. 15, pc). It extends from the coxal process to the verasternite, thereby connecting the episternum and verasternite. The episternum has never been known to occur in front of the precoxale, but the cervical sclerites are always situated anterior to it. The large sclerite which lies in front of the coxa and the "proepisternum," also lies in front of the precoxale. Hence this sclerite cannot be the prothoracic episternum, or "proepisternum," but must be a lateral cervical sclerite. In *Dolerus* the precoxale is in the process of disappearing (Fig. 12, pc). It is represented on either side of the prothoracic verasternite by a small sclerite (Fig. 12, pc), while in *Macroxyela* it has entirely disappeared (Fig. 14), In the latter insect however, the verasternite has greatly increased in size and may possibly represent the fusion product of the verasternite and part of the precoxale (Fig. 14, vs). A cleft indicating a possible splitting of the lateral cervical is seen in *Macroxyela* (Fig. 14). The episternum and epimeron are clearly marked off by sutures in the prothorax

of *Dolerus* and are seen to be much reduced in size (Fig. 12, es, em_1). From the above facts, it seems very probable that the large sclerite in sawflies, which Snodgrass, '10, calls the "proepisternum," is really a large lateral cervical sclerite, fused with the episternum and in some cases with the epimeron also. The fact that an internal process is present at the point of articulation of the "proepisternum" with the head (Fig. 15, ap), signifies that this plate is a cervical sclerite, since a similar process is found on the lateral cervicals of several other insects as in *Gryllus*, *Forficula*, etc.

When the epimeron is absent in the prothorax of sawflies, Snodgrass, '10, considers the internal process or pleural arm, as apparently not the homologue of the pleural arm of the other segments, since it does not arise between the plates (Fig. 14, pla). This may be true, but in all cases the pleural arm is joined to the furca of the furcasternite as in other segments and in other insects. If the epimeron has apparently disappeared in the prothorax of some sawflies, it may be represented by a part of the pleural arm itself, especially if it be true that the pleural arm is formed by an infolding of the integument. Thus it would seem more probable that the pleural arm in the prothorax of sawflies, in which the epimeron is absent, is the homologue of the pleural arm of other segments and of other insects.

Several theories have been formulated to account for the origin of the cervical sclerites.

Straus-Durckheim, '28, suggested that the cervical sclerites represent the remains of two segments, situated originally between the head and prothorax. He designated them by the term "pieces jugulaire."

Newport, '39, considered them as detached portions of the prothorax and called them the prothoracic "paraptera."

Lowne, '70, regarded the cervicals as a part of the labial segment or last cephalic segment of the head. This theory was later adopted and supported by Huxley, '85, Comstock, '02, Riley, '04 and others. Although Riley, '04, regards the lateral cervical sclerites as the pleurites of the labial segment of the head, he also states that part of the pleural region of the labial segment is already included in the head capsule. Lowne, '70, applied the terms "condyle" to the lateral cervicals and

"cephlo-sternum" to the ventral cervicals. Huxley, '85, used the term cervical sclerites to designate the neck plates.

Lowne, '90, considered the cervicals as detached portions of the prothorax, thereby accepting the theory formerly proposed by Newport, '39.

Verhoeff, '02-'04, adopted and elaborated the theory advanced by Straus-Durckheim, '28, viz., that the cervicals represent two segments originally situated between the head and prothorax. He termed the neck region the "microthorax" and designated the various sclerites by the terms, "coxopleure," "anapleure," etc. This theory was severely criticized by Silvestri, '02, Börner, '03, Voss, '04, Desguin, '08, and others. They proved conclusively that Verhoeff's "microthoracic" theory was unsupported by anatomy, embryology, musculature, etc.

Berlese, '06, regarded the cervical sclerites as belonging to the head and prothorax.

Snodgrass, '08, adopted Verhoeff's theory of the "microthorax," but later Snodgrass, '09, repudiates the "microthoracic" theory, adopting the term "cervicum" of Crampton, '09, for the neck region.

SUMMARY.

The thorax is composed of three segments, the pro-, meso-, and metathorax.

All compound segment theories are not based upon enough facts to be acceptable at present.

The thorax of primitive insects, larvae, etc., is composed of numerous small sclerites, which become fused to form the sclerites of the higher insects.

A secondary fusion or a splitting of sclerites often occurs. Certain specialized forms often retain some characters of primitive insects.

The tergum of winged insects is composed of two sclerites, which are usually subdivided into regions.

The wing articulates with two processes on the lateral margin of the tergum and with the alar plates at the base of the wing. Ventrally it articulates with the pleural wing process.

The pleuron is represented by a single sclerite in some primitive insects. (*Eosentomon*).

The pleural suture is always present, together with the apodeme, and they are probably formed by the infolding of the integument due to muscular stress or similar causes.

The pleuron may be connected dorsally with the tergum at its anterior and posterior end by a bridge and ventrally with the sternum in a similar manner.

The episternum and epimeron are subdivided into an upper and lower region in some insects. (*Mantispa*).

The sternum is composed of five subdivisions in a few insects. (*Capnia*, *Ectobia*, etc.)

The presternite is present as a large, oval sclerite, lying in front of the prothoracic verasternite in *Capnia* and *Forficula*. It is considered as a large ventral cervical by most writers.

The large sclerite which lies in front of the coxa in the prothorax of sawflies, is largely composed of the lateral cervical, fused with the episternum, and in some cases with the epimeron also.

The cervical sclerites are detached portions of the head and prothorax and are homologous with the intersegmentalia, which are probably derived from the segments directly anterior and posterior to them.

In some insects the coxa is composed of two parts, the meron or posterior portion and the veracoxa or anterior portion. The meron is part of the coxa and derived from it.

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TERMINOLOGY.

The sub-figures 1, 2, and 3 indicate that the sclerites belong to the pro-, meso- and metathorax respectively.

a—sclerite attached to base of head in Periplaneta.
aba—anterior basalar.
ac—antecoxale.
ad—apodeme.
ap—apophysis.
atn—antetrochantin.
ba—basalar sclerites.
cm—coximarginal sclerite.
cs—cervical sclerite.
cx—coxa.
cxp—coxal process.
dcs—dorsal cervical slcerite.
el—elytra.
em—epimeron.
es—episternum.
esp—anepisternum.
f—furca.
fs—furcasternite.
g—suture dividing episternum into two regions.
h—halteres.
i—intersegmentalia.
inplt—inner pleurotergite.
iplt—inferior pleurotergite.
kem—katepimeron.
lcs—lateral cervical sclerite.
m—meron.
mp—meropleurite.
msn—mesonotum.
msst—mesosternum.
mt—mediotergite.
mtn—metanotum.
mtst—metasternum.
o—suture dividing episternum and precoxale in *Periplaneta.*
oplt—outer pleurotergite.
pba—posterior basalar sclerite.
pc—precoxale.
pem—postepimeron.
pes—pre-episternum.
pfs—postfurcasternite.
pla—pleural arm.
plc—pleurocoxale.
pls—pleural suture.
plt—pleurotergite.
pltn—pleurotrochantin.
plwp—pleural wing process.
pn—pronotum.
prs—presternite.
prsc—prescutum.
psl—postscutellum.
ptn—post-trochantin.
ptp—pteropleurite.
sa—subalar sclerite.
sc—scutum.
scsl—scutoscutellum.
sl—scutellum.
sp—spiracle.
spa—abdominal spiracle.
spplt—superior pleurotergite.
ss—spinasternite.
stc—sternocoxale.
stp—sternopleurite.
tm—tergum.
tn—trochantin.
tnl—trochantinelle.
tnm—trochantin major.
vcs—ventral cervical sclerites.
vcx—veracoxa.
vs—verasternite.
w—wings.
Ist a—1st abdominal segment.

EXPLANATION OF PLATES.

Owing to the nature of the thorax, the figures are necessarily somewhat diagramatic, but as far as possible, represent the natural condition of the sclerites as they occur in the thorax of these insects. In lateral views the anterior end faces the right side of the page. In ventral and dorsal views the anterior end faces the top of the page.

PLATE I.

Fig. 1. A lateral view of the thorax of *Tipula*, including part of the dorsum and the first abdominal segment. Head, wing and the greater part of each leg removed.

Fig. 2. A lateral view of the thorax of *Leptis*, including part of the dorsum and the first abdominal segment. Head, wing and the greater part of each leg removed.

PLATE II.

Fig. 3. A three-quarters view of the thorax of *Periplaneta*, showing the ventral and lateral sclerites, together with the edge of the pronotum and wings. Head and the greater part of each leg removed.

Fig. 4. A three-quarters view of the thorax of *Capnia*, showing the ventral and lateral sclerites, together with the edge of the pronotum and wings. Head and the greater part of each leg removed.

Fig. 5. Dorsal cervical sclerites of *Periplaneta*.

Fig. 6. Dorsal intersegmentalia, occurring between the pro- and mesothorax of *Corydalis*.

PLATE III.

Fig. 7. A three-quarters view of the thorax of *Gryllus* including the lateral and ventral sclerites, together with the edge of the pronotum and wings. Head and greater part of each leg removed.

Fig. 8. A three-quarters view of the thorax of *Forficula*, including the lateral and ventral sclerites and the edge of the pronotum and wings. Head and greater part of each leg removed.

Fig. 9. A three-quarters view of the prothorax of *Ectobia lapponica*, including the ventral and lateral sclerites, and the edge of the pronotum. Head and greater part of each leg removed.

Fig. 10. A lateral view of the mesothorax of *Corydalis*, including part of the tergum and sternum. Most of the leg removed.

PLATE IV.

Fig. 11. A lateral view of the thorax of *Tabanus*, including part of the dorsum. Head, wing and the greater part of each leg removed.

Fig. 12. Ventral view of the prothorax of *Dolerus*, showing ventral and lateral sclerites. Head and greater part of each leg removed.

Fig. 13. Lateral view of the thorax of *Chrysopa* including part of dorsum and first abdominal segment. Head, wing and greater part of each leg removed.

Fig. 14. A ventral view of the prothorax of *Macroxyela*, showing ventral and lateral sclerites. Head and most of each leg removed.

Fig. 15. Ventral view of the prothorax of *Abia*, showing ventral and lateral sclerites. Head and most of each leg removed.

Fig. 1

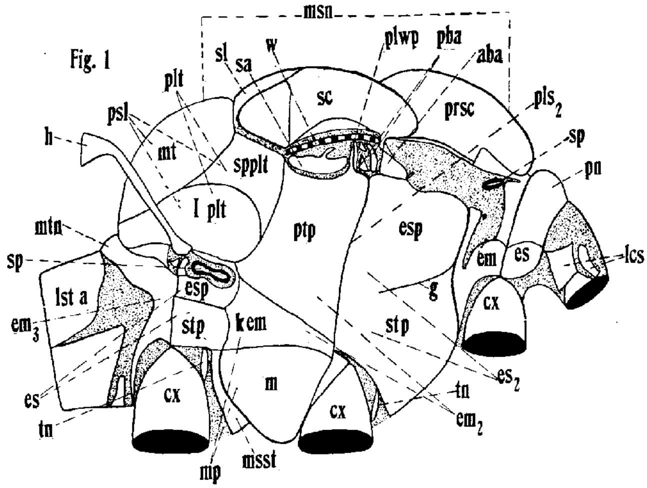
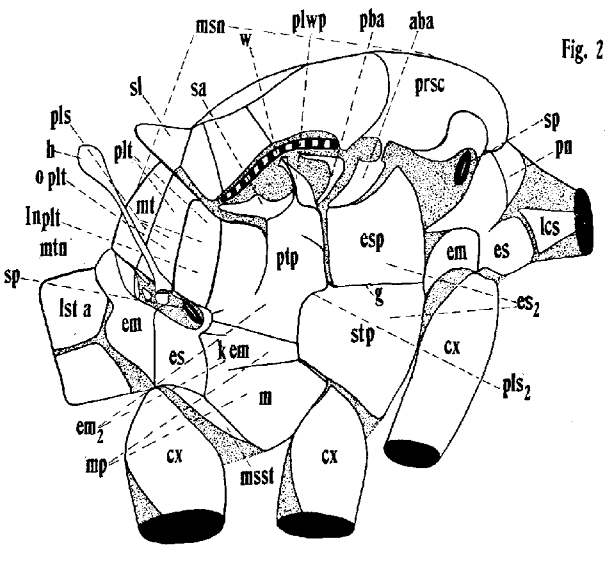


Fig. 2



J. F. Martin.

Fig. 5

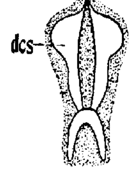


Fig. 6

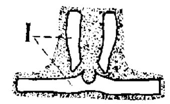


Fig. 3

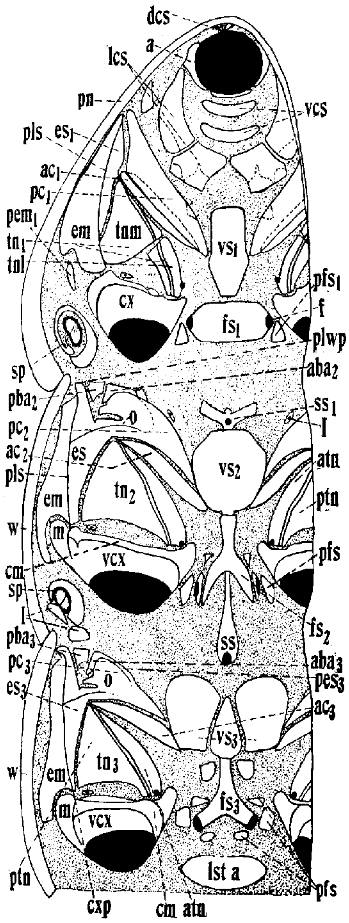


Fig. 4

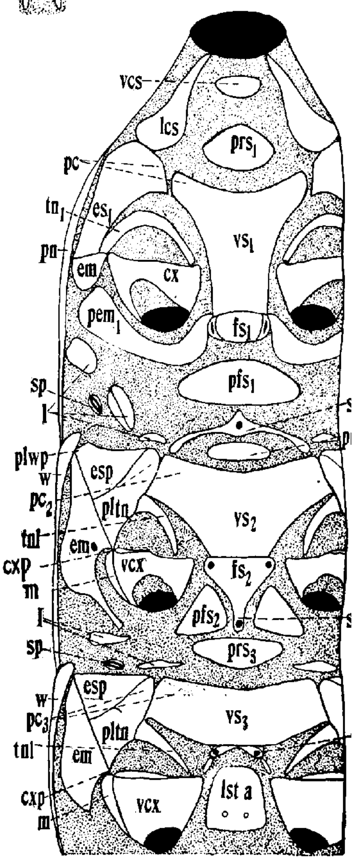


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Fig. 7

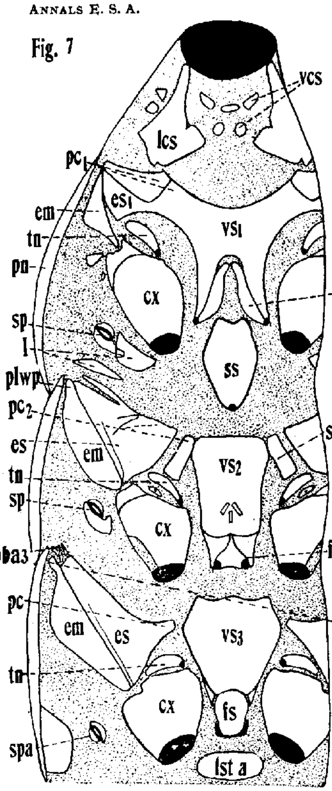

Fig. 8

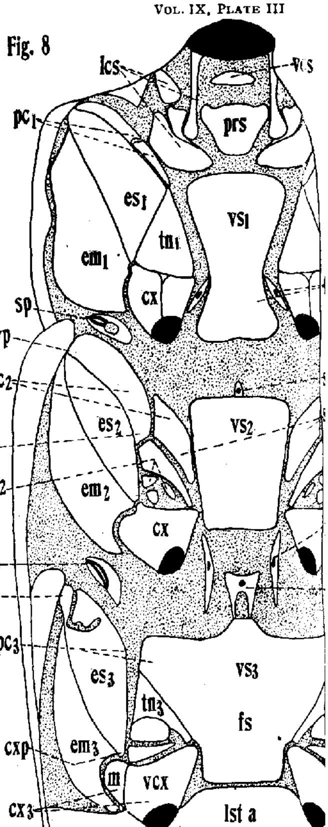

Fig. 9

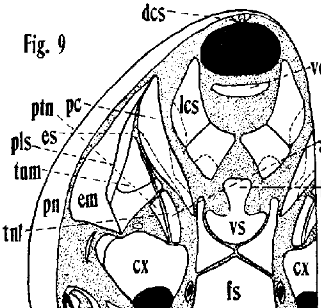

Fig. 10

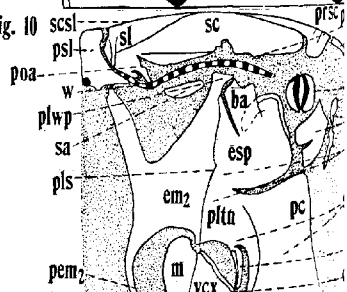

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Fig. 11

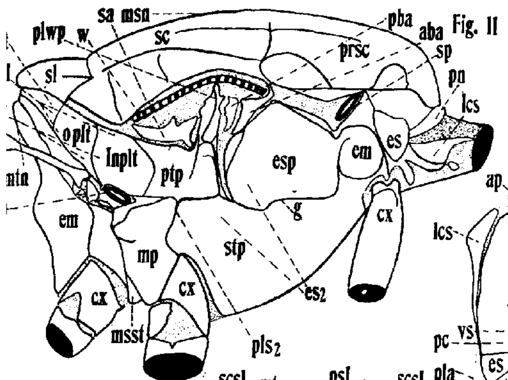


Fig. 12

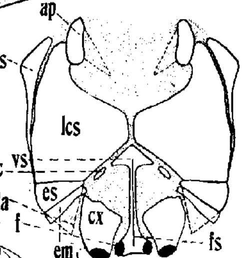


Fig. 13

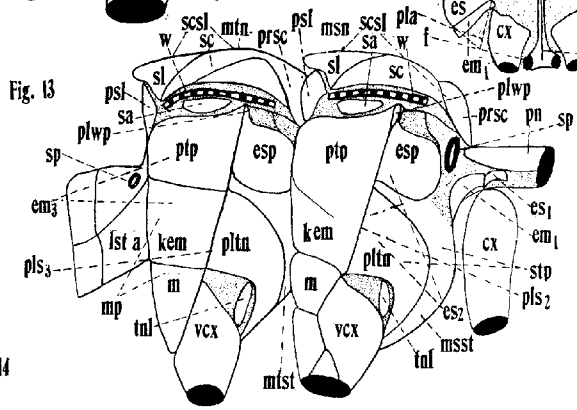


Fig. 14

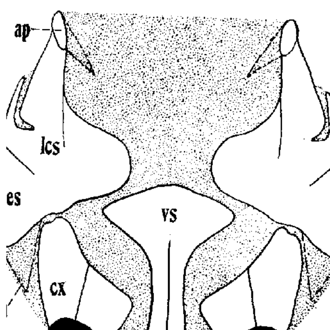
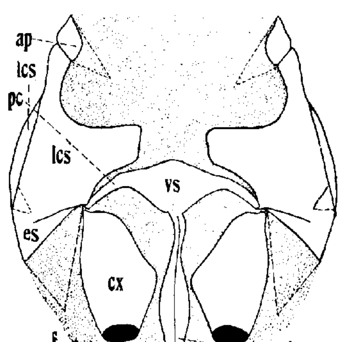


Fig. 15



J. F. Martin.

PRIORITY IN FAMILY NAMES AND RELATED MATTERS.

By E. P. VAN DUZEE,*
University of California, Berkeley, Cal.

What would we say if some iconoclast in nomenclature should promulgate the dictum that the type of each genus must be the earliest described species now included in that genus? But when we stop to think of it that would be no more revolutionary than Kirkaldy's scheme to make the earliest described genus in each family the type genus of that family and when necessary to rename the family so it shall bear the name of such genus; a scheme, strange to say, that has had a considerable following among continental Hemipterists. Kirkaldy was led to his action through his efforts to restrict the limits of certain of the families of the earlier writers on Hemiptera and to use the names already applied for his new family concepts. Had he adopted instead the "historical method" used by him in naming genotypes and treated family names by the same rule he applied to generic names most of his difficulties would have vanished at once.

In 1911 Dr. Horvath gave us in outline his plan to apply the rule of priority to family names as it has long been applied in the case of generic and specific names. This it seems to me is the only logical way to treat family names. I can conceive of no argument against such a course that would not apply with equal force to the application of the rule of priority to the names of genera and species.

In working out the nomenclature of my Catalogue of North American Hemiptera I adopted Dr. Horvath's plan in its broader principles, changing a few details where its practical application developed weak points. I have become much interested in the results of my undertaking and thought it might not be inappropriate to lay before this Society an outline of the "rules" if such they might be called, for the formation and limitation of the names of families and other group names higher than genera, used by me in the preparation of this catalogue. In brief these are as follows:

*Read before the Berkeley meeting of the Entomological Society of America, August 5th, 1915.

First. The name of each family must be derived from that of some included genus and such genus then automatically becomes the type of such family, and the family name must follow that of its type genus through all its mutations. Hence, if the name of the type genus is found to be preoccupied the family must take the new name applied to such genus and not the next oldest name used in the family, as that would virtually be changing the type and thus breaking down the very foundation of the plan.

Second. A family name cannot be rejected when the limits of the family are extended or restricted any more than in the case of a generic name. The family name merely means the group of genera related to the type genus be that group large or small.

Third. While desirable it is not essential that the name of a family as first founded be in the correct latin form. Colloquial names when formed from a valid generic name so as to indicate indubitably the type genus must be accepted. Similarly, a family name founded with a different termination or in a different category is to be accepted and its termination changed to bring it into accord with the International Rules. Hence, a subfamily or tribe may be raised to family rank by changing its termination to *idæ*.

Fourth. When two or more families are united the name having priority must stand. Page precedence must not be confounded with priority, it has little to do with nomenclature and should be applied only as a last resort.

Fifth. However desirable it is not essential to validity that the founding of a new family be accompanied by a description or even a summary of family characters. If the name be properly formed from that of a generic name that genus becomes its type and it is to consist of the genera related to that type genus. If characters are named and a later writer gives the family a wider or narrower scope he cannot rename it on the assumption that he has founded a new family.

Sixth. If a family be divided into subfamilies, tribes or divisions the section in each category containing the type genus must bear the name of that genus with the termination *inæ* for subfamilies, *ini* for tribes and *aria* for divisions. This is in

accord with the International Committee's rule that in a genus divided into subgenera the one containing the type species shall bear the name of the genus.

So much for family names. I now wish to call attention to a few other points in nomenclature that have forced themselves upon me during the preparation of this catalogue.

First, and perhaps most important: What constitutes the founding of a genus? I have looked in vain in the International Rules for an answer to this question, but one conclusion seems incontrovertable: *No genus is valid until a type species can be named for it.* Thus a genus described without the mention of a species is invalid until a species is included in it and it must then date from the inclusion of such species, and must take for its author the one assigning the species.

Second. A genus founded without a description but with a definite statement or indication that it is founded on a certain species is valid if the species named has been properly described. If we refuse to accept such a generic name we must also refuse to accept a genus founded in connection with a species in a single description.

Third. A mere catalogue name is a *nomen nudum* and is invalid except in cases where it is perfectly evident that it was given to replace a preoccupied name, or a name cited in error.

Fourth. Emendations are not desirable except where there has been an obvious misprint or error in spelling. Thus I have restored to their original form most of the numerous names emended by Amyot and Serville.

Fifth. The selection of a genotype is a matter of great importance as in many cases a selection may change the meaning or scope of a genus. In my catalogue I have used the earliest type fixation known to me that does not conflict with the International Rules and common sense. Among the early writers it is sometimes difficult to be certain just what should be considered as type fixations. So far as I can discover Lamarck, in 1801, was the first to say he was indicating the type species in the Hemiptera. Fabricius certainly indicated type species for most of the genera in the Systema Rhyngotorum, in 1803, by repeating with italics the generic characters in his description of the type species. That this was his intention in repeating these

generic characters we are informed by Fallen who was almost or quite a contemporary of Fabricius. Latreille in 1810 was the next to say he was naming types for the genera of the Hemiptera, followed by Laporte in 1832 and Westwood in 1840. Kirkaldy claims that Latreille in his work of 1802, in naming "examples" under each genus, was really naming types but I have been unable to accept this as he so obviously was selecting the species most likely to be known to those students living in France and did not restrict himself to them in his definite type fixations of 1810. Some of those early systematists named two types to a genus and in such cases I have followed Kirkaldy in rejecting both and taking the next valid fixation.

In the matter of species there is but one point I wish to bring out. As I understand the International Rules subgenera are placed on the same footing as genera and subspecies and varieties on the same footing as species. Hence, subgeneric names are preoccupied by generic, and subspecies and variety names are preoccupied by those of species, and vice versa. This principle has not been recognized in the Oshanin Catalogue but it is really essential that it be generally adopted on account of the frequency with which a form is shifted from one category to another.

Before closing, I wish to call attention to a matter that it seems to me is of prime importance and that is what I would call the validation of entomological literature. If you will take the trouble to look up the matter you will find that most of the changes in names come through different methods of selecting genotypes and through varying views regarding the validity of certain early papers. After we think we have the nomenclature of some group of insects well settled some one will dig up an ancient catalogue and discover there new names, generic and specific, and armed with these he will proceed to demolish our nomenclature. Our most crying need now is for a validated list of early books and papers, published, say, prior to 1850, and I would strongly urge that a committee be appointed, preferably by the International Zoological Congress, to go over the zoological bibliographies, which are now fairly complete, and decide which works are valid and which are mere catalogues or are too ephemeral to have a standing in zoological nomenclature. That we should discard mere catalogue names

is I think irrefutable. Anyone who thinks otherwise will certainly be cured of this delusion if he will read Stephen's introduction to his Catalogue of 1829, where he says in effect that he does not care to take either the time or trouble to prepare descriptions of the numerous new genera he has established in his catalogue but will leave that task to anyone who feels inclined to undertake it, with the inference that it could be done by someone whose time is less valuable than his. I am sure no sane person would think of using Stephen's names after reading that preface, or perhaps I should say of crediting them to Stephens. If the Zoologists as a whole are not willing to undertake the preparation of such a validated bibliography I can see no reason why the entomologists should not do so independently. It would then be up to the Zoologists to endorse the list or to give their reasons for not doing so. What we most need now is stability and that we can never have while each individual entomologist is free to accept as valid or to reject as invalid the numerous uncertain papers and books that appeared in the early days of our science and may still be imminent.

A METHOD OF KEEPING ALCOHOLIC SPECIMENS.

By F. C. Bishopp,
Bureau of Entomology, U. S. Department of Agriculture.

The following method of preserving alcoholic specimens has been used at the Dallas laboratory for the Bureau of Entomology for a number of years. It has been found to be more satisfactory than any other system tried.

The specimens to be preserved are placed in the smallest size shell vials, which will contain the specimens, and a brief, finely printed label. For minute specimens, such as mites, mallophaga, etc., shell vials 25 mm. in length by 8 mm. in diameter are used. In fact, this size vial is employed for all specimens which can be placed in them without crushing. About three other sizes of shell vials are employed for the larger material. For short, thick specimens short vials of large diameter are used. The shell vials containing the specimens and labels are stopped with a small compact wad of absorbent cotton and the vials are then inverted and placed in a larger container. The container employed by us is a shell vial, 100 mm. long, by 28 mm. in diameter. A small layer of absorbent cotton is placed in the bottom of the container before the vials are inserted. This prevents danger of cracking the bottom when the small vials are dropped in. Each container is limited to one species, or if very little material of a certain kind is to be collected one of the large vials may contain a genus or even larger groups.

Ordinarily, however, each container is limited to a species, and a label bearing the name of the species is placed on the outside of the container, as is also the container number. Containers of the above diameter will hold conveniently seven or eight of the smallest size vials in one layer, and two layers may be placed in each. The container is then filled with alcohol in order to cover the vials and a good quality of cork used to close it. In the Dallas collection the material is then filed systematically by orders and alphabetically by genus and species under these. The containers are kept in wooden racks sufficiently wide to hold two of the bottles with a partition between and twelve inches long. A label is placed on the end of the rack to show the material it contains, and cardboard riders are set on the

longitudinal strip which divides the two sides of the rack. These are labelled to designate the genus, or in case a large number of containers is used for one species, the species name may be shown on these guides. For very large specimens we find it unnecessary to employ the double tube system. The accompanying illustration shows a rack partially filled with containers. Note the cardboard riders which are used as guides and the label on the end of the rack.

A number of advantages have been found in this method. It saves space by having the material more concentrated than where collections are preserved in individual vials; these large

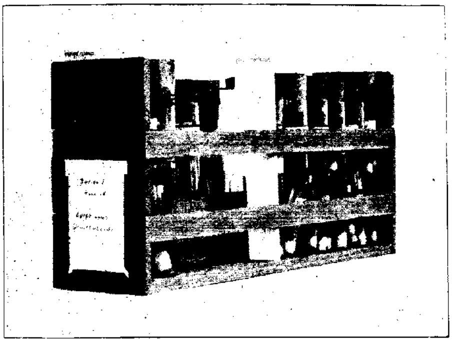


Figure 1

containers do not dry out so rapidly as small ones; there is not the usual trouble with the corks becoming hard and loose, owing to direct contact with the alcohol, and the specimens will remain moist as long as there is the smallest trace of alcohol in the container; the collection presents a neatness and uniformity which adds to its appearance and aids in classification and ease of finding material; the large size of the containers permits of having a label stuck to each, thus avoiding tag labels tied on small vials or loss of time necessary to look at the labels within hundreds of alcoholic vials; there is a large saving by not having to go through a great number of small vials in filling them, as each container will hold from one to fourteen of the individual vials. Furthermore, it is possible to allow an untrained helper to fill the containers as the material itself is never touched and there is no danger of losing specimens by overflowing individual vials.

Of course the kinds of racks in which the material is kept and the system of filing them should depend upon the individual needs and conditions, but the essential system, that of having a large outside container with a number of individual vials therein, may be employed in almost any museum or laboratory.

At Dallas it has been the practice to accession all material before it is put away, each lot receiving an accession number. The labels are made as brief as possible, usually only the name of the species and accession number being given. When it is desired to get more complete data the accession catalogue (in card form) may be consulted. Our labels are made with India ink. They are thoroughly dried by heat before using. We have found it possible to save time in the future by writing the accession number on both sides of each label. The method of labelling, of course, is also subject to change according to individual preference. As far as possible, the vials containing material of a given species are placed in the containers in numerical sequence. When time permits they may be arranged in perfect numerical order, and the number of the container (the series containing each species to begin with No. 1) as well as the inclusive accession numbers of the material in each inserted on the container label.

For convenience sake we have found it advisable to divide the entire alcoholic series into three parts, numbering these series I, II and III. Series I contains all the material under the accession catalogue which it is desired to keep; series II (the "life history series") contains bred material which is designed to illustrate all of the different stages of an insect or other form; series III is composed of specimens for exchange, or in other words a duplicate series.

I have recently observed a number of different systems for arranging alcoholic material in different laboratories and museums, and have heard several say they did not like the double-tube system. In these cases, however, the containers used were very little larger than the vials containing the specimens, therefore each container was occupied by but a single vial of specimens. This only tends to increase the volume of the collection, does not facilitate refilling with alcohol, and the containers do not hold enough alcohol to prevent frequent fillings. I am of the opinion that if the double-container system, as described above, is employed, it will be found to be very free from objectionable points.

NOTES ON THE BIOLOGY OF PARAPHELINUS SPECIOSISSIMUS GIRAULT.

By W. R. McConnell,

Scientific Assistant, U. S. Department of Agriculture, Bureau of Entomology, Cereal and Forage Insect Investigations.

It is well known that the Chalcidoids of the Tribe *Aphelinini* are among the most important parasites of Scale Insects, particularly of the *Diaspinæ*, and that they also parasitize *Aphididæ* and *Aleyrodidæ*. The only exceptions appear to belong to the genus *Paraphelinus*, erected by Perkins in 1906 (Bull. 1, part 8, Report of Work of the Experiment Station of the Hawaiian Sugar Planter's Association, 1906, p. 264) to contain his *P. xiphidii*. In describing the species *P. tomaspinis*, Dr. Howard has given a compact summary of the facts known regarding the biology of this genus (Proc. Ent. Soc. Wash., XVI, 1914, pp. 81–82), which is as follows:

"Perkins's *P. xiphidii* was reared from the eggs of *Xiphidium varipenne* Swezey. The only other species so far discovered, viz.: *P. speciosissimus* Girault (Journ. N. Y. Ent. Soc., 1911, p. 181) and *P. australiensis* Girault (Archiv fur Naturgeschichte, 1913, pp. 74–75, Ab. A. 6 heft), were both described from single captured specimens, so that their host relations are unknown. The receipt of the new species here described from Mr. P. L. Guppy, of Trinidad, who reared it from the eggs of the sugar cane leaf-hopper, *Tomaspis varia*, makes it probable that all species of this interesting genus are parasites in the eggs of Orthoptera and Homoptera that are inserted in twigs or canes. This would be an unique feature in *Aphelinine* biology (the other forms all ovipositing only in Coccidæ, Aphididæ and Aleyrodidæ) were it not for the old disputed species *Agonioneurus locustarum* Giraud (placed in *Aphelinus* by Dalla Torre) and which was described by Dr. J. Giraud in his Memoir on the insects which live upon the common rose (Verh. d. Zool.-Bot. ges. Wien., Vol. 18, 1863, pp. 1278–1279) and which he reared from the eggs of *Xiphidium fuscum* F. It seems to me quite possible that in the old *A. locustarum* we may have another species of *Paraphelinus*. There is nothing in the original description which would seriously deny this guess, except the absence

of the hairless discal streak on the primaries, and this is obscure in the species about to be described."

We were quite surprised to find last July that an *Aphelinine* was emerging from Hessian Fly puparia. These have been determined by Mr. A. B. Gahan, of the Bureau of Entomology, as *Paraphelinus speciosissimus* Girault. As will be noted from the above quotation, it requires only a slight elaboration of Dr. Howard's theory to include as a host for this genus the Hessian Fly, whose puparia resemble superficially the eggs of an Orthopterous insect and are embedded in the stems of wheat.

The original specimens upon which the present data are based were secured from wheat stubbles collected by Mr. P. R. Myers of the Bureau of Entomology. The puparia were removed from these stubbles and placed in cages containing nothing else. Adults reared from these puparia were used by the writer in experimentally parasitizing other puparia known to be absolutely free from any parasites, and three more successive generations have thus been reared from the original parents, The rearing has been conducted at Hagerstown, Md., and all data here given apply to laboratory conditions at that point.

DISTRIBUTION.

Girault's original specimen was collected on a granary window at Urbana, Ill. In spite of the fact that we have reared large numbers of Hessian Fly puparia from various points in Pennsylvania, Maryland, Virginia and West Virginia, we have thus far secured this parasite only from the following six localities in central Pennsylvania: Linden, Montoursville, Muncy, Montgomery, Northumberland, and Andersonburg. The first five localities are in two adjoining counties along the Susquehanna River, where a serious outbreak of Hessian Fly occurred. The last locality is about fifty miles southwest from Northumberland, and here only about 31% of the stubbles were infested by the Hessian Fly. Out of a total of 3165 puparia secured from all of these localities, only 17, or a little more than .005%, were parasitized by this Chalcidoid. Some fields in each locality yielded none of these parasites, while in the other fields the percentage of parasitization varied from 0.14% at Andersonburg to 3.2% in one field at Muncy. In the latter field Mr. Myers estimated that 65% of the stubbles were fly-infested.

ADULT.

The adults are beautiful little insects with head and abdomen almost entirely black, thorax and legs chiefly light yellow, a dark band across the front wings and ovipositor exserted. The females average about 0.8 mm. long; the males, about 0.5 mm.

This species is a primary multiple parasite of the Hessian Fly. It has been demonstrated repeatedly that it is a primary parasite, not only by rearing it from the Hessian Fly, but by experimentally parasitizing Hessian Fly puparia known to be free from parasites. It would seem to promise much as a primary parasite of this host because several adults usually emerge from a single host. This is not due to polyembryony but to multiple egg deposition, as shown by the recovery by dissection of eggs deposited in puparia. The number of adults emerging from a puparium varies from 1–10, with an average of about 7, for puparia experimentally parasitized. This average is considerably lower under field conditions as they obtained last year. Eleven eggs have been dissected from one host parasitized in the laboratory, and another contained twenty-one living larvæ, two dead larvæ and two dead eggs. In this case the evident excessive parasitization had already begun to right itself.

The adults emerge through a round hole in the middle region of the puparium, and usually there is a single one. Sometimes two exit holes are cut, and occasionally three. When there is a single exit hole it is frequently much larger than would seem necessary. The exit holes vary in size from 0.2 mm. to 0.45 mm. with an average for ten puparia of 0.33 mm., while according to measurements made by Mr. Myers the largest diameter of the thorax averaged 0.24 mm. for the females, while in the males it is only 0.18 mm.

All adults usually emerge from a puparium about the same time, but occasionally they may emerge throughout the day, and in one case the last female emerged two days later than the others. In many cases both sexes emerge from the same puparium. In laboratory cages where both sexes were introduced, about 18% of the progeny were males. In one cage into which only unfertilized females were placed, all of the progeny were males. It is apparent from this that the species is

arrhenotokous, but there has been no opportunity for carrying parthenogenesis through several successive generations.

When there is opportunity, mating occurs shortly after emergence, and there is little doubt that one male is capable of fertilizing several females. Oviposition may begin very shortly after emergence. In fact, it is difficult to remove females from cages and make sure that they have not oviposited in other puparia in the same cage. The females continue oviposition for several days. In cages, adults usually do not live longer than three to six days, but if they do not oviposit their life may be much longer. In one cage they have lived seventeen days. They feed on sugar solution, but have not been observed feeding at punctures in the host made by the ovipositor.

The females will oviposit in purparia concealed in young wheat plants and in dry dead stubbles as well as in uncovered puparia. It seems to make no difference whether the puparium contains a larval or a pupal host, as both stages are successfully parasitized.

EGG.

The eggs of this parasite are deposited in the body cavity of the host. Ten eggs averaged 0.166 mm. in length by 0.057 mm. in greatest width. They are white and translucent and the chorion is devoid of sculpture. The eggs are ovate and stalked, the stalk being about one-third the length of the egg proper. The stalk is attached excentrically at one end of the egg, slightly curved toward its main axis, and is wide at the base tapering rapidly to a rather bluntly rounded apex.

LARVA

Nearly grown larvæ are yellowish white with the exception of the light brown mandibles. The head is about twice as wide as long and bears at each antero-lateral region a large conical process directed forward. These lateral projections are peculiarly striking and may be simply a means of exposing more surface to the fluids of the host. The front between these processes is almost straight, but there is a decided concavity ventrally between the lateral processes. The mandibles are simple, conical, sharply pointed, slightly curved, and the tips slightly overlap. The mouth opens just below them. The body apparently consists of thirteen segments. These are distinct in the anterior region but posteriorly are difficult to distinguish.

There is a pair of short tubercles on the ventral region of the prothorax and these are evidently vestigial prothoracic legs. No spiracles have been observed, but they probably do not open up until just before pupation. The body is devoid of hairs. The alimentary canal is a large sac closed behind and filled with yellowish material. There is a posterior anal notch but the proctodæum apparently lacks a lumen. A pair of salivary glands may be seen starting back from a common duct originating ventral to the mouth cavity. While alive the larvæ exhibit a rhythmic opening and closing of the mouth, but the mandibles are not moved while this is in progress, and periodic swallowing movements occur.

In full grown larvæ the body is somewhat shorter and broader and the processes on the head slightly less conspicuous. Larvæ at this stage are about 1 mm. long and 0.3 mm. wide.

Pupation takes place inside the skin of the host. The latter is rounded out into a more or less elliptical cell and becomes dry and light brown in color. The larvæ have a strong tendency to arrange themselves before pupation with their heads diercted toward the center of this cell, and in this cell just prior to pupation they void their excrement, which consists of numerous dark reddish brown disks.

PUPA.

The pupa when first formed, is white with an elongate orange spot, showing through the middle of the dorsum of the abdomen. The average of four pupæ gave a length of 1.063 mm. by 0.356 mm.

LIFE HISTORY.

Accurate data for the length of the various stages of this parasite have not been secured. However, in one cage where the adults began to oviposit in host puparia on July 29th, larvæ almost full-grown in hosts almost entirely consumed were dissected out on August 3d, after a period of only five days. This shows that at this season development is very rapid and that the egg and larval stages are very short. In another cage numerous pupæ and no larvæ were dissected August 4th from host puparia into which parasites began to oviposit July 24th. Adults emerged from these pupæ August 13th and 14th, showing that the pupa stage required at least nine days. From these and other cages it was found that complete development from

oviposition to emergence required from eighteen to twenty days at this season of the year. Developmental processes slow up with the approach of cold weather. We do not know the number of generations per year, but beginning July 24th, we ran one cage in which three generations matured by October 19th, the first beginning to appear August 20th, the second September 14th and the third on the date mentioned. Assuming that the parent generation required twenty days, there could be four generations from July 4th up to the last of October. Under field conditions at the points where the original specimens were collected, this last generation might not be produced.

In any event, there is time enough in one season for an enormous multiplication of this parasite. Puparia collected shortly before emergence of the host would probably show a much higher percentage of parasitism than that shown by our figures. Consequently, *Paraphelinus speciosissimus* may prove in the future to be an important agent in the control of a serious outbreak of the Hessian Fly and the fact that one host may serve to develop as many as ten adults would indicate that it could maintain its numbers at a relatively high level during seasons when the host is scarce.

ADDITIONAL NOTES ON THE GENUS PTEROCOMMA.

By H. F. Wilson.

The writer has published in the December, 1915, issue of the Annals, a paper under title, "A Synopsis of the Aphid Tribe *Pterocommini*." Mr. J. J. Davis has called to my attention two citations not listed in my paper, both of which include descriptions of new species.

The first paper the writer does not have, but it was published by Alexander Mordwilko in 1901, in Vol. 33, Horæ Society of Entomology of Russia. A new species is described as *Cladobius steinheili*.

Mr. Davis has loaned me one slide containing five specimens, only one of which seems to be mature. The specimens are similar to *Pterocomma bicolor* Oestlund, but may be a distinct species. There were not a sufficient number of specimens present to determine the species accurately.

The second paper was by Miss Edith Patch in Bull. 213 of the Maine Experiment Station in which Miss Patch describes a species as new under the name of *Melanoxantherium antennatum*. This species is distinctly different from all of the other members of this group in generic characters and does not belong in the genus *Pterocomma* nor in the tribe *Pterocommini*.

Mr. Davis also suggests that *Cladobius rufulus* Davidson is a synonym of *Pterocomma bicolor* Oestlund rather than *P. populeus* Linn. In this connection, I may say that these two species or almost identically similar ones are found along the Pacific Coast and they have both been confused under the name of *rufulus*. Mr. Davidson also seems to have confused them and the slides sent to me by him seemed nearer to *populeus* than to *bicolor*. *Pterocomma bicolor* covers an extremely wide distribution and shows great variation in the size and shape of the nectaries.

FRANCES MARION WEBSTER.

AN APPRECIATION.

The Entomological Society of America has in the death of its honored President lost not only its chief officer but one of its most loyal members and supporters throughout its entire career.

It seemed therefore especially fitting that it should give expression to its sorrow and an appreciation of its profound regard for Professor Webster without waiting for the usual formal resolutions adopted by the Society at its annual meeting in recognition of its honored dead.

With hearty accord of officers and editorial board the writer undertakes to express the appreciation which we believe must be felt by every member of the Society.

Professor Webster has been a long time and trusted friend and the writer feels a sense of personal loss far beyond expression in the usual phrases. A personal acquaintance and friendship of more than a quarter century has suddenly ceased but the memory of that friendship and the influence of his enthusiasm and the spirit of his fine ideals are possessions to be held for life.

Professor Webster built himself into the structure of American Entomology by persistence and force of character and in face of difficulties which would have discouraged any man of less determination. His work was varied and embraced a wide range of Entomological Science; all was sincere and honest and much of it will endure as of permanent value to mankind. He brought to each task the energy of purpose and the foundation of fruitful experience. The loyalty of his [illegible] and assistants testify to the sincerity and wisdom of

I saw him last on Sunday a few hours before his death and in spite of his desperate condition he showed the force and the cheerful hopefulness characteristic of the man. He said that he realized it was perhaps unwise for him to make the trip to Columbus but that he was especially anxious to meet his Entomological friends and expressed his pleasure in the meeting and keen regret that two of his oldest friends among the Entomologists whom he had hoped to meet had not been present. I feel that I may fairly convey to them and all his host of friends the farewell greeting of a fallen comrade.

He was keenly appreciative of the honor of his election to the Presidency and it seems especially fitting that this tribute of his co-workers should have been conferred in time for him to have the pleasure it might afford him.

Prof. Webster was born in Lebanon, N. H., August 8th, 1849, and died in Columbus, Ohio, January 3d, 1916. As Assistant to the State Entomologist of Illinois; Agent of the U. S. Division of Entomology in the Department of Agriculture; Entomologist of the Ohio Experiment Station; and lastly, Chief of the Division of Cereal and Forage Crop Insects in the Bureau of Entomology he stepped from one important duty to another and in his last position doubtless wielded his greatest influence upon the growth of Economic Entomology.

Practically his whole life has been devoted to his favorite study and he died, as doubltess he would have wished, while in active participation of duties connected with his life work. American Entomology has lost a leader but will hold and treasure an example of devotion and fruitful effort.

HERBERT OSBORN.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

Columbus Meeting.

The first meeting of the Tenth Annual Meeting of the Entomological Society of America was held in Botany and Zoology Hall of the Ohio State University, on Wednesday, December 28, and was called to order by President Vernon L. Kellogg at 2:00 P. M. The following papers were presented:

D. M. DeLong, Ohio State University—Notes on the Jassoidea of Tennessee.

N. E. McIndoo, U. S. Bureau of Entomology—The Olfactory-Gustatory Sense of the Honey Bee. Read by title.

William Moore, University of Minnesota—How Gases enter Insects.

A Franklin Shull, University of Michigan—Parthenogenesis and Sex in *Anthothrips verbasci*. Read by title.

Eric S. Cogan, Ohio State University—The Homopterous Mouth.

H. C. Severin, South Dakota State College of Agriculture—The Life-History, Economic Importance, and Control of the Carpenter Moth in South Dakota. Read by title.

F. E. Chidester, New Jersey Agricultural Experiment Station—The Influence of Salinity upon the Development of the Salt Marsh Mosquito. Read by title.

W. R. McConnell, U. S. Bureau of Entomology—Notes on the Biology of *Paraphelinus speciosissimus* Girault. Read by title.

C. H. Richardson, New Jersey Experiment Station—The Attraction of Diptera to Ammonia. Presented by Thomas J. Headlee.

The President was directed by motion to appoint the following committees on organization and named the following:

Committee on Resolutions—J. M. Aldrich, Paul S. Welch and Edith M. Patch.

Committee on Nominations—F. M. Webster, T. J. Headlee and William Moore.

Auditing Committee—William A. Riley, Eric S. Cogan and C. L. Metcalf.

The Society then adjourned for the afternoon.

The meeting for the Annual Public Address was held in the meeting room of the Southern Hotel and was called to order [illegible] P. M. by President Kellogg. The speaker of the evening

was Dr. C. Gordon Hewitt, Dominion Entomologist, who gave "A Review of Applied Entomology in the British Empire." The meeting was well attended and the visiting entomologists were entertained after the address by the Entomologists of Ohio at a smoker and burlesque, which all agreed in pronouncing a great success.

The Society convened on Thursday, December 30, at 10:00 A. M. in a joint session with the American Association of Economic Entomologists, with President Vernon L. Kellogg in the chair, for the presentation of the two following papers:

L. O. Howard, Chief U. S. Bureau of Entomology—An Appreciation of the Hawaiian Parasite Introduction Work.

F. M. Webster, U. S. Bureau of Entomology—Ethnoentomology. Presented by E. P. Felt, because of the illness of Mr. Webster.

The joint session was adjourned and the following paper was read:

J. L. King, University of Illinois—The Life-history of *Pterodontia*.

The Society then adjourned until 2:00 P. M.

The Secretary upon the reconvening of the Society, presented the following report for the Executive Committee:

REPORT OF THE EXECUTIVE COMMITTEE.

The annual meeting of the Executive Committee was held in the office of Professor Herbert Osborn, at the Ohio State University, Wednesday, December 29th, with the following members present: James S. Hine, J. M. Aldrich, Herbert Osborn, W. A. Riley and A. D. MacGillivray.

The most important matter considered by the Executive Committee in the interim since the last Annual Meeting was the selection and appointment of Dr. C. Gordon Hewitt to give the Annual Public Address at the Columbus meeting.

The following new members were elected by the Executive Committee June 1st, 1915:

F. W. Dry	N. K. Jardine
G. A. Chandler	O. S. Wescott
F. A. Fenton	R. L. Nougaret
C. M. Packard	Howard Curran

The following members have died during the past year:

Donaldson Bodine	E. E. Phillips
Roe Niver	Andrew Rutherford

The following resignations were presented and accepted:

Newton L. Partridge	Charles Piper Smith
E. Dwight Sanderson	Howard E. Weed

The following were elected to membership by the Executive Committee at its meeting on Wednesday:

R. A. Muttkowski	C. F. Stiles	L. B. Ripley
J. S. Wade	E. K. Parker	J. M. Robinson
H. H. Jewett	E. B. Powers	F. O. Coe
J. S. Rogers	H. V. Heimburger	P. A. Munz
S. L. Alexander	F. Silvestri	F. L. Thomas
D. G. Tower	R. T. Cotton	G. H. Vansell
George Newman	F. H. Benjamin	B. P. Young
L. O. Jackson	C. F. W. Muesebeck	F. G. Carnochan
J. K. Thibault	J. L. Hypes	J. W. Chapman

The following report of receipts and expenditures was submitted by the Treasurer:

RECEIPTS.

Trust Funds:		
Life Membership Fees deposited with Cleveland Trust Company, Cleveland, Ohio, December 1, 1914	$150.00	
Life Membership Fee of Seth Bunker Capp deposited with Cleveland Trust Company, Cleveland, O., Feb. 4, 1915	50.00	
Samuel Hubbard Scudder Fund deposited with Cleveland Trust Company, Cleveland, Ohio, May 18, 1915	35.00	
		$235.00
Cash:		
Cash on deposit in the First National Bank of Champaign, Illinois, December 14, 1914	$136.46	
Cash received from Herbert Osborn, Managing Editor of the ANNALS	262.14	
Cash collected as dues	693.69	
Interest on Fees of Life Members, Scudder Fund, and interest compounded from May 3, 1912 to July 1, 1915	17.19	
		1,109.48
		$1,344.48

BALANCE.

Bills Paid, ANNALS:		
Annals and Separates, September, 1914	192.20	
Annals and Separates, December, 1914	235.80	
Annals and Separates, March, 1915	270.00	
Annals, Engraving	90.20	
		$814.56
Bills Paid, Secretary-Treasurer's Office:		
Stamps and Stamped Envelopes	$47.42	
Printing and Supplies	60.18	
Stenographer and Office Help	38.85	
Writing Certificates for 1911	11.80	
		158.25
Thomas Say Foundation, printing		9.12
Life Membership Fees deposited with Cleveland Trust Company, Cleveland, Ohio, December 1, 1915, at 4%		200.00
Samuel Hubbard Scudder Fund deposited with Cleveland Trust Company, Cleveland, Ohio, December 1, 1915, at 4%		35.00
Interest on Fees of Life Members, interest compounded, and Samuel Hubbard Scudder Fund, deposited with Cleveland Trust Company, Cleveland, Ohio, December 1, 1915, at 4%		17.19
Cash on deposit in the First National Bank of Champaign, Illinois, December 27, 1915		110.36
		$1,344.48

The names of the following Fellows were recommended to the Executive Committee for election as Honorary Fellows:

Stephen Alfred Forbes
Samuel Wendall Williston.

These recommendations were adopted by the Executive Committee and in accordance with the Constitution, were referred to the Fellows for a mail ballot. This ballot was taken during the past year, and the Executive Committee now declares them duly elected.

The following report was submitted by the Managing Editor of the Annals of the Entomological Society of America:

REPORT OF THE MANAGING EDITOR OF THE ANNALS.

The volume for the year 1915 has been kept within four hundred pages, as the income for the year did not seem to warrant further expansion. We have had but few orders from outside the United States and fewer sets of volumes have been placed this year than last.

The total receipts for the office have been $323.41:

Subscription account	$222.55
Sale of back numbers	53.71
Sale of reprints	47.15

The expenses for various items have been $61.27:

Stamps, express, and post office charges	$29.98
Stenographic help and office supplies	20.54
Engraving	10.75

Amount turned over to the Treasurer $262.14.

It may be mentioned that the prospective income for the coming year will insure a fair volume and the maintainance of the Annals at its present standing may be considered as practically assured.

Respectfully submitted,

HERBERT OSBORN, *Managing Editor.*

The following, J. H. Emerton, C. Gordon Hewitt and Lawrence Bruner, were elected as members of the Editorial Board of the Annals for three years. The terms of J. H. Comstock, C. J. S. Bethune and C. W. Johnson having expired.

The Secretary was directed by the Executive Committee at the Washington meeting to sell the collection of books and papers presented to the Society by Samuel Hubard Scudder at the time he was elected an Honorary Fellow. Their sale was accomplished during the present year for the sum of thirty-five dollars and this sum was deposited with the Cleveland Trust Company, as directed by the Executive Committee, as already stated in the report of the Treasurer. The Executive Committee moved that fifteen dollars of the interest that has accrued to date be transferred to this fund, making it a fund of fifty dollars, which was to be known as the Samuel Hubbard Scudder Fund.

The Secretary presented for the Temporary Committee of the Thomas Say Foundation appointed at the Philadelphia meeting, the following report:

REPORT OF THE THOMAS SAY FOUNDATION.

The Temporary Committee of the Thomas Say Foundation, by special permission of the Executive Committee of the Entomological Society of America, sent to each member of the Society with the call that was issued for the San Francisco meeting, the following letter:

May 15th, 1915.

Members of the Entomological Society of America:

The Entomological Society of America at its Philadelphia meeting established the Thomas Say Foundation for the publication of works dealing with American insects. These works to be limited to those of a monographic or bibliographic character and to be of such size as to make a separate volume of one hundred or more pages. The persons named at the head of this sheet were appointed a temporary committee with power to solicit funds, to choose works for publication, to determine the form of the publication, and to print such volumes for which the committee has funds and which it considers worthy of publication.

The committee on publication must have funds before the publication of such a series of volumes can be inaugurated. With the consent of the Executive Committee of the Entomological Society of America, the committee of the Thomas Say Foundation are sending the following appeal and proposition to the members of the Society.

It is agreed that those persons who will make a preliminary subscription of ten dollars ($10.00) towards the Thomas Say Foundation are to be considered charter subscribers and are to receive such volumes as the Foundation may issue, equivalent to the amount of their subscription. The Executive Committee of the Entomological Society of America also authorizes the publication committee of the Thomas Say Foundation to guarantee to those persons making a subscription of ten dollars, that in case no volumes of the Thomas Say Foundation are issued, that they shall be freed from the payment of all annual dues to the Entomological Society of America for a period of five years or for an amount equivalent to their subscription.

It is hoped that all those persons who are interested in the development of such a series of monographs and catalogues of American insects as is contemplated in the Thomas Say Foundation will aid the Committee.

Respectfully submitted,

MORGAN HEBARD, *Treasurer.*
ALEX. D. MACGILLIVRAY, *Editor.*

SUBSCRIPTION.

I send herewith the sum of ten dollars ($10.00) to Morgan Hebard, Treasurer of the Thomas Say Foundation as a preliminary subscription to the said Foundation with the understanding that I am to be considered a charter subscriber, that I am to receive such volumes of the Foundation as are issued equivalent to the amount of my subscription, and that in case no volumes are issued the Entomological Society of America is to credit me with the payment of my dues to the Society for a period of five years.

Name..

Street..

Town.. *State*..

The following report was received from the Treasurer of the Foundation:

I regret that I will be unable to attend the Columbus meeting and would therefore like to submit to you the report of the Thomas Say

Foundation. The receipts to date total $170.00 and no expenses as yet have been incurred. The following are subscribers:

William Barnes	William S. Marshall
P. P. Calvert	Isabel McCracken
T. D. A. Cockerell	A. L. Melander
William T. Davis	Herbert Osborn
G. P. Englehardt	William A. Riley
M. Hebard	Mrs. A. T. Slosson
S. Henshaw	P. H. Timberlake
A. D. MacGillivray	E. B. Williamson

Entomological Branch, Dept. Agr., Ottawa, Ont.

It would seem wholly ill-advised to use any of this money at present. I think that by again sending out appeals we could possibly increase the amount quite considerably. In the meantime, every effort should be used to bring this Foundation before the notice of those who are able and might be willing to establish a reasonably large endowment. Until sufficient funds are available to insure at least some annual income, no publication could well be undertaken with any prospect of continued activity. If any suggestions can be made for the furtherance of this work, I will be glad to co-operate to the best of my ability. The funds are deposited in the name of the Foundation with the Girard Trust Company, of Philadelphia. This institution does not allow interest on deposits of less than $500.

MORGAN HEBARD, *Treasurer.*

The report of the committee on ways and means, its adoption by the Executive Committee of the Entomological Society of America, their appointment of a temporary committee of five, and the election of a treasurer and an editor by this temporary committee, has already been detailed in the proceedings of the Philadelphia meeting of this Society.

Several methods appear to be possible in financing the projected publication. An endowment sufficiently large to provide constant income for printing would be ideal. Almost equally satisfactory would be a working capital of about twenty thousand dollars, which would return in the sale of the publications so that it could be used indefinitely. Special appeal to one of the large scientific foundations might secure the printing of some work of especial timeliness and value. And last, but not least important, subscriptions from members might enable a beginning to be made.

The subscription method offers the most available means for the early issuance of a volume and while a fund of some size is not essential for the carrying out of this method, yet it would be necessary for the members of the committee individually or collectively or some friend of the committee to be financially responsible for the composition, printing, and binding of the first volume until sufficient funds had been accumulated for its sale to recompense the printer. This method has been used successfully by some of the European societies, notably the Ray Society of England, which was founded in 1844, and has issued two

or three volumes each year. Although the Ray Society has been publishing volumes for seventy years, yet so far as can be judged from its financial reports, which were issued annually in one of its volumes, it has never had an endowment fund, but has depended entirely upon annual subscriptions to meet the expense of publication. Whether the number of entomologists, schools, libraries, experiment stations and universities, that would be willing to subscribe for such volumes as might be issued by the Thomas Say Foundation would be large enough to meet the expenses of publication has not been determined by the temporary committee.

There has been expended of the fifty dollars set aside by the Executive Committee at the Philadelphia meeting for the use of the temporary committee of the Thomas Say Foundation, the sum of nine dollars and twelve cents for the printing of letter heads, the letter above described, and envelopes. The permission to include this letter with the call for the San Francisco meeting did not increase the amount of postage per letter for the Entomological Society of America, so that there has been no expense to the Society other than the printing named above.

Respectfully submitted for the temporary committee,

ALEX. D. MACGILLIVRAY.

The Executive Committee named the following temporary committee to look after the Thomas Say Foundation for the year 1916: J. M. Aldrich, Nathan Banks, A. D. MacGillivray, E. B. Williamson, Morgan Hebard, Treasurer, and Philip P. Calvert, Editor.

On motion the report of the Executive Committee was adopted.

REPORT OF COMMITTEE ON NOMINATIONS.

The undersigned, your committee on nominations, giving the matter as careful consideration as time would permit, desire to present the following names for your consideration:

First Vice-President: E. P. Felt, New York State Entomologist, Albany, N. Y.

Second Vice-President: A. L. Melander, Washington Agricultural College, Pullman, Washington.

Secretary-Treasurer: J. M. Aldrich, U. S. Bureau of Entomology, West Lafayette, Indiana.

Additional Members of the Executive Committee:

H. T. Fernald, Massachusetts Agricultural College, Amherst, Massachusetts.

W. E. Britton, Connecticut Agricultural Experiment Station, New Haven, Connecticut.

P. J. Parrott, New York Agricultural Experiment Station, Geneva, New York.

E. D. Ball, Dean Utah Agricultural Experiment Station, Logan, Utah.

C. Gordon Hewitt, Dominion Entomologist, Ottawa, Canada.

On the question of the nomination of President, the committee became divided, two of the members of committee felt that the proper person for this position was the chairman of the committee, Mr. F. M. Webster, U. S. Bureau of Entomology, Washington, D. C., and the majority vote of the committee decided to recommend Mr. F. M. Webster for our next President.

Member of Committee on Nomenclature:

E. P. Felt, New York State Entomologist, Albany, N. Y.

(Signed) THOMAS J. HEADLEE,
WILLIAM MOORE.

On motion, the Secretary was instructed to cast a ballot for the officers named and they were declared elected.

COMMITTEE ON RESOLUTIONS.

Your Committee on Resolutions beg leave to report as follows:

Our meeting at the Ohio State University has been rendered unusually pleasant by the hospitality of the entire staff of the institution, and especially by the kindness and careful attentiveness of the members of the Department of Zoology and Entomology, to all of whom our thanks are due.

We congratulate Professor Herbert Osborn on the fine and servicable building in which his work is now carried on, and desire to express our continued obligation to him for his services as Managing Editor of the Annals.

The retirement of Professor MacGillivray from the post of Secretary-Treasurer should not pass without acknowledgment of his efficient service; he has performed the numerous duties of his office with rare fidelity and good judgment, and the present standing of our Society is in considerable measure due to this fact.

Respectfully submitted,

J. M. ALDRICH,
PAUL S. WELCH,
EDITH M. PATCH.

On motion, the report was adopted.

REPORT OF THE AUDITING COMMITTEE.

COLUMBUS, OHIO, Dec. 30, 1915.

We, the undersigned, have this day examined the accounts of Alexander D. MacGillivray, Treasurer and Secretary of the Entomological Society of America, for the year ending December 27th, 1915, and the accounts of Herbert Osborn, Managing Editor of the Annals of the Entomological Society of America for the year ending December 1st, 1915, compared the vouchers therewith and found them correct and properly cast.

(Signed) WILLIAM A. RILEY,
ERIC S. COGAN
C. L. METCALF.

On motion, the report was adopted.

REPORT OF THE COMMITTEE ON NOMENCLATURE.

Pursuant to instructions given at the last Annual Meeting, two members of the Committee on Nomenclature suggest the following rule in relation to designations of supergeneric value. Tribe, subfamily, family, and superfamily names should be formed by adding the endings *ini, inae, idae,* and *oidea,* respectfully to the root of an included, persumably typical and valid genus.

The Committee has not been able to prepare the desired list of the more important names in each order which are in danger of being lost or changed in sense by a strict application of the rules of nomenclature, and it takes this opportunity of inviting specialists in the various groups to submit a list of names with recommendations as to the same.

Respectfully submitted,

E. P. FELT,
T. D. A. COCKERELL,
Members of the Committee in Agreement.

The other member of the Committee, Mr. Nathan Banks, is opposed to piece-meal efforts along nomenclatorial lines and to any exceptions to the law of priority and has stated that he does not care to serve upon the Committee.

On motion the report of the Committee on Nomenclature was adopted.

The following amendment to the Constitution of the Entomological Society of America submitted at the Philadelphia meeting, was read and the following substitution for Section 1, as printed in the proceedings of the Philadelphia meeting, is offered by the Executive Committee of this meeting, so that the amendment as a whole, to constitute Article VIII of the Constitution is as follows:

ARTICLE VIII.

SECTION 1. *Name*—There is hereby established a standing committee of the Society under the name of "The Thomas Say Foundation."

SEC. 2. *Purpose*—The purpose of this Foundation is for the publication of works of a monographic or bibliographic character on the insects of North America.

SEC. 3. *Publication*—Each publication shall be a volume complete in itself, and numbered consecutively.

SEC. 4. *Committee*—This committee shall consist of six members, four of them to be elected by the Executive Committee of the Society, two of them retiring annually, and an Editor and a Treasurer, to be designated by the Executive Committee.

SEC. 5. *Powers*—This Committee is empowered to determine all matters concerning the publication.

SEC. 6. *Funds*—They are also empowered to solicit, hold, invest, and expend funds committed to their care; only the interest of any endowment to be available.

SEC. 7. *Responsibility*—The Society shall be in no way responsible for debts contracted by this Foundation, unless previously authorized by the Executive Committee.

SEC. 8. *Reports*—The Editor and Treasurer shall present a report of their operations and expenditures to the Executive Committee at each Annual Meeting, and the accounts of the Treasurer shall be audited by the Auditing Committee of the Society. These reports shall be published as a part of the proceedings of the Executive Committee of each Annual Meeting.

On motion, the amendment as above stated, was adopted.

Objections were raised to the time of scheduling the meetings of the Entomological Society of America during Convocation Week. The earlier meetings of the Society were held during the first days of the week, but at the Philadelphia meeting were changed to the last two days of the week and during this meeting were held on Wednesday and Thursday. The plan of holding the meetings at the end of the week was severely criticized by some members as well as the arrangement at this meeting, although both arrangements were at the request of certain members. It seemed to be the unanimous opinion of all members present at the Columbus meeting that the meetings of the Entomological Society of America and of the American Association of Economic Entomologists should not be in session at the same time, because the membership of the two societies are practically identical and the members desire to attend all the meetings of both societies. The following motion was offered and carried:

Resolved, that it is the wish of the members of this Society that its annual meeting for the reading of papers be held, as formerly, at the beginning of Convocation Week, and that the Secretary is requested to confer with the Secretary of the American Association of Economic Entomologists to see if this can not be arranged.

The following papers were then presented:

C. L. METCALF, Ohio State University—Metamorphosis of the Syrphidæ.

ALVAH PETERSON, University of Illinois—The Epipharynx and Hypopharynx of the Diptera.

W. E. BRITTON, Connecticut Agricultural Experiment Station—Notes on Certain European and Other Foreign Insects Occurring in Connecticut. Read by title.

PHILIP GARMAN, University of Illinois—Specific and Individual Variation in the Gills of the Nymphs of the Zygoptera.

V. E. SHELFORD, University of Illinois—An Analysis of the Color-Patterns of Cicindela.

C. C. HAMILTON, University of Illinois—Notes on a Twig-Dwelling Cicindelid.

S. B. FRACKER, Assistant State Entomologist of Wisconsin—The Immature Stages of *Schroeckensteinia*, a New Raspberry Pest.

PAUL S. WELCH, Kansas Agricultural College—Contribution to the Biology of Certain Aquatic Lepidoptera. Read by title.

A. C. BURRILL, University of Wisconsin—House-Ant Trails and their Bearings on Economic Control. Presented by S. B. Fracker.

FREDERICK KNAB, U. S. National Museum—The Dispersal of Diptera beyond their Natural Habitat. Read by title.

The exhibition was held in the Zoology and Botany building under the direction of Professor James S. Hine. The following exhibits were shown:

J. H. EMERTON, Boston, Massachusetts—Circulating Collection of Spiders.

EDITH M. PATCH, Maine Agricultural Experiment Station—Host Plant Outlines of a few Aphids Based upon Original Observations in Maine.

E. W. BERGER, Entomologist of Florida State Plant Board—Fungus Parasites of Scale-Insects and White-Flies in Florida.

DON C. MOTE, Ohio Agricultural Experiment Station—Warble-Fly Injury.

J. R. WATSON, Florida Agricultural Experiment Station—Life-History of *Anticarsia gemmatilis*.

R. W. COLEMAN and W. A. RILEY, Cornell University—Wax Model of Repugnatorial Glands and their Muscles in *Anasa* nymph.

On motion, the Society adjourned to meet in one year with the American Association for the Advancement of Science at New York, N. Y.

ALEX. D. MACGILLIVRAY, *Secretary*.